United States Department of Agriculture
Forest Service

Francis Marion National Forest

Draft Forest Plan Assessment

Francis Marion National Forest, Berkeley and Charleston Counties, South Carolina

December 2013

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Francis Marion National Forest
Draft Forest Plan Assessment
Berkeley and Charleston Counties, South Carolina

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Table of Contents

1 Introduction 1
1.1 Overview 1
1.2 Location of the Plan Area 2
1.3 History and Distinctive Features of the Plan Area 2
1.4 Important Ecological Influences on the Plan Area 4
1.4.1 Climate 4
1.4.2 Dominant Ecosystems 4
1.4.3 Terrain 4
1.4.4 System Drivers 4
1.4.5 Vegetation 5
1.5 Relevance of National Forest System Lands 5
1.6 Important Social and Economic Influences on the Plan Area 5
1.6.1 Demographics and Population Trends 5
1.7 Current Contribution to Ecological, Social, and Economic Sustainability, and Multiple Uses 6
1.7.1 Ecological, Social, and Economic Sustainability and Multiple Uses 6
1.7.2 Key Ecosystem Services and How Communities Benefit 7
1.8 Risk Factors and Uncertainty 9
1.9 Best Available Science 9
1.10 Public Involvement 9
1.10.1 Fall 2012 Public Meetings 9
1.11 Summary of the Assessment 11
1.11.1 Timber Harvest 12
1.11.2 Impacts on Forest Revenues to Counties 12
1.11.3 Protection of At-risk Species 12
1.11.4 Wildlife Habitat 12
1.11.5 Resource Potential 12
1.11.6 Acres Classified as Wetlands 12
1.12 What is the Next Step? 12
2 Assessing the Ecological Sustainability and Diversity of Plant and Animal Communities 15
2.1 Terrestrial Ecosystems, Aquatic Ecosystems, and Watersheds 15
2.1.1 Terrestrial Ecosystems 15
2.1.2 Aquatic Ecosystems 47
2.1.3 Watersheds 63
2.2 Air, Soil, and Water Resources and Quality 75
2.2.1 Air 75
2.2.2 Soil 89
2.2.3 Water Resources and Quality 93
2.2.4 Water Quality 111
2.2.5 Riparian Areas, Wetlands and Waters 121
3 Additional System Drivers 133
3.1 Introduction 133
3.2 Climate Change 133
3.3 Insects and Disease 145
3.4 Wildland Fire/Fuels 147
3.5 Invasive Species 210
3.5.1 Invasive Species: Plants 210
3.5.2 Invasive Species: Aquatic Nuisance Species 214
3.5.3 Invasive Species: Terrestrial Animals 215
3.6 Natural Vegetation Succession 220

3.7 Natural Disturbance 222
3.7.1 Preliminary Findings 222
3.8 Human Disturbance 230
4 Carbon Assessment 233
5 Threatened, Endangered, Proposed and Candidate Species, and Potential Species of Conservation Concern Present in the Plan Area (At-Risk Species) 241
5.1 Federally Listed Threatened, Endangered, Proposed, and Candidate Species – Plants 243
5.2 Potential Species of Conservation Concern – Plants 247
5.3 At-Risk Terrestrial Wildlife 249
5.3.2 Threatened, Endangered, Proposed and Candidate Species 253
5.3.3 Potential Species of Conservation Concern 271
5.4 Aquatic At-Risk Species 273
6 Social and Economic Assessment 277
7 Ecosystem Services: Assessment of Benefits 315
8 Multiple Uses 325
8.1 Introduction 325
8.2 Recreation 325
8.3 Fish and Wildlife 326
8.4 Timber 343
8.5 Range 349
8.6 Watershed 349
9 Assessing Recreation Settings, Opportunities, Access and Scenic Character 359
9.1 Recreation Settings 380
9.2 Recreation Opportunities: Developed 382
9.3 Recreation Opportunities: Dispersed 397
9.4 Recreation Access 401
9.5 Scenic Character 402
10 Renewable and Nonrenewable Energy and Mineral Resources 405
11 Infrastructure 413
11.1 Introduction 413
11.2 Transportation 414
11.2.1 Roads 415
11.2.2 Trails 421
11.3 Structures 422
11.3.1 Facilities–Non-Recreation 422
11.3.2 Facilities–Recreation 424
11.3.3 Bridges (Roads and Trails) 426
12 Federally Recognized Indian Tribes 429
13 Cultural and Historic Resources and Uses 431
14 Land Status and Ownership, Use and Access Patterns 443
14.1.2 Land Status and Ownership 443
14.1.3 Land Use 447
14.1.4 Access Patterns 449
15 Designated Areas 453
15.1 Statutorily Designated Areas 453
15.1.1 Wilderness 453
15.2 Administratively Designated 460
15.2.2 Introduction 461
15.2.3 Inventoried Roadless Areas 461
15.2.4 Swamp Fox National Recreation Trail 462
15.2.5 Santee Experimental Forest 462

15.2.6 Research Natural Area 463
15.3 Regional Forest Designated Areas 464
15.3.2 Historical Areas 465
15.3.3 Botanical Areas, Geological and Research Natural Areas 466
15.3.4 Scenic Areas 467
15.3.5 Eligible Wild and Scenic Rivers 468
15.4 Administrative Sites 468
15.4.2 Seed Orchard and Progeny Test Areas 469
15.4.3 Francis Marion Office and Ranger Station 470
15.4.4 Witherbee Office, Work Center and Housing Complex 470
References 473
Appendix A: Plants of Potential Conservation Concern and At-Risk on the Francis Marion National Forest 517
Appendix B: Trends, Core Area, and Other Information for the Red-cockaded Woodpecker 525
Appendix C: Riparian Areas, Wetlands, Lakes, Streams, Tidal or Freshwater Marsh, Springs, and Seeps 533

List of Tables

Table 2-1. Terrestrial ecosystem acreage, both within proclamation and administrative boundaries 23
Table 2-2. Estimates of existing acres of longleaf forest type by ownership category 25
Table 2-3. Upland longleaf and wet pine savanna ecological systems by 1996 management area based on 2013 ecological modeling 27
Table 2-4. Longleaf condition classes from 2010 longleaf assessment, by Longleaf Ecosystem type (in acres) 28
Table 2-5. Trends in possible old growth in longleaf forest types 30
Table 2-6. Possible old growth (≥110 years) by Longleaf Pine Ecological System 30
Table 2-7. Prescribed fire in ecological systems on the Francis Marion National Forest (2005–2012) 31
Table 2-8. Acreage in grassland, savanna, woodland, and forest structural classes by ecological system based on LIDAR-derived canopy cover using GIS 33
Table 2-9. Ecological departure rankings for Upland Longleaf and Wet Pine Savanna ecosystems[1] 34
Table 2-10. Invasive plant species counts by ecological system 36
Table 2-11. Acres by forest type group from FSVEG, 2013, and by ecological system 37
Table 2-12. Percent of stands typed and managed as potential hard-mast producing hardwoods, as a percent of total forested acres 39
Table 2-13. Ecological departure rankings for upland hardwood ecosystems on the Forest, where low=0–33%, medium=34–66%, and high=67–100% levels of departure 40
Table 2-14. Structural ecological departure rankings for forested wetlands on the national forest, where low=0–33%, medium=34–66%, and high=67–100% levels of departure 43
Table 2-15. Possible old growth forested wetlands 43
Table 2-16. Structural ecological departure rankings for maritime forests on the national forest, where low=0–33%, medium=34–66%, and high=67–100% levels of departure 47
Table 2-17. Occurrence of nuisance species on the Francis Marion National Forest 57
Table 2-18. Table number of fish species captured per Forest watershed. 59
Table 2-19. Emission of sulfur dioxide, nitrogen oxides, and particulate matter within the airshed for the years 2002, 2005, and 2008 79
Table 2-20. Percentage of ownership in each of the soil acidic deposition critical load exceedance categories based upon McNulty et al. (2007) 88
Table 2-21. Total mean daily load (TMDL) target dates that are to be addressed with implement plans to treat the water quality impairments by SC DHEC and affected parties 112

Table 2-22. Riparian area acreage as estimated by ecological classification on the Francis Marion National Forest ... 127
Table 2-23. Comparison of two approaches used to estimate riparian areas, wetlands and aquatic areas 127
Table 2-24. Extent of wetlands, by type ... 129
Table 2-25. Potential tree species that could be used for wetland restoration ... 130
Table 3-1. Summary of annual and seasonal historic temperature (°F) from 1980–2009 ... 136
Table 3-2. Summary of annual and seasonal historic precipitation (inches) from 1980–2009 ... 136
Table 3-3. Summary of mean annual historic and future climate under the A2 scenario ... 138
Table 3-4. Summary of mean seasonal historic and future climate under the A2 scenario ... 140
Table 3-5. Land ownership distribution ... 147
Table 3-6. Major periods of human-caused fire regimes in the South ... 151
Table 3-7. Fire regime groups and descriptions ... 155
Table 3-8. Francis Marion fire severity type acreage breakdown ... 155
Table 3-9. MFRI Breakdown (as based upon the LANDFIRE Vegetation Dynamics Model Database) and terrestrial ecosystems ... 156
Table 3-10. Percent of 160,000 burned by season ... 162
Table 3-11. Forest plan monitoring questions ... 162
Table 3-12. Prescribed fire accomplishment by season ... 163
Table 3-13. Francis Marion fire regime condition class breakdown ... 165
Table 3-14. Federal Register/SILVIS wildland-urban interface ... 170
Table 3-15. HFRA designated wildland-urban interface ... 173
Table 3-16. On-Forest values at risk wildland-urban interface designation ... 174
Table 3-17. Combined wildland-urban interface ... 176
Table 3-18. Mechanically treated acreage breakdown, 2005 to 2012 ... 180
Table 3-19. Analysis area fire statistics relative to the State of South Carolina (1992–2012 Fires) ... 183
Table 3-20. Additional pocket card-specific statistics ... 188
Table 3-21. Number of fires per size class ... 189
Table 3-22. Analysis area weather indices per large fire events ... 190
Table 3-23. Current pocket card thresholds ... 190
Table 3-24. Hauling chart: Tactical interpretations from flame length ... 191
Table 3-25. Scott and Burgan adjective class definitions for predicting fire behavior ... 192
Table 3-26. Weather scenarios ... 194
Table 3-27. Fuel Models of the Francis Marion National Forest ... 194
Table 3-28. BehavePlus potential fire behavior outputs ... 195
Table 3-29. Nonnative invasive plants documented on the Francis Marion National Forest ... 212
Table 4-1. 2011 Francis Marion National Forest carbon stocks (metric tons) ... 237
Table 4-2. Proportions of 2011 carbon stocks by forest type and dominant tree size class ... 237
Table 4-3. Fate of carbon from annual average forest harvests, Francis Marion National Forest (in metric tons) ... 238
Table 4-4. Total GHG emissions 2009 (includes land use change) ... 239
Table 5-1. American chaffseed monitoring trends, Francis Marion National Forest ... 244
Table 5-2. Threatened, endangered, proposed and candidate species considered in the 2013 assessment of the Francis Marion National Forest ... 254
Table 5-3. Acreage and percentage of area by types for stands 1MBM and over per acre, and stands under 1 MBM per acre (acquired and approved) ... 257
Table 5-4. Example burn matrix from Desoto National Forest, which could be modified for use within *A. cingulatum* and *L. capito* habitat on the FMNF ... 269
Table 5-5. Potential terrestrial animal species of conservation concern ... 272
Table 5-6. Aquatic at-risk species found on the Francis Marion National Forest ... 275
Table 6-1. Population totals: current and historic ... 281
Table 6-2. Components of population change between 1990 and 2010 ... 281

Table 6-3. Population projections 2015–2030 282
Table 6-4. People per square mile 283
Table 6-5. Median age, 2010 285
Table 6-6. Migration of individuals 65+, 2007–2011 285
Table 6-7. Educational attainment, percent of persons age 25+ 286
Table 6-8. Unemployment in study area, 2005–2011 289
Table 6-9. Per capita income, 1990 and 2011 (adjusted for inflation and reported in 2011 dollars) 293
Table 6-10. Average annual wages, 2011 293
Table 6-11. Non-labor income as a share of total personal income, 2011 295
Table 6-12. Poverty rates, 2011 296
Table 6-13. Activity participation on the Francis Marion-Sumter National Forests 299
Table 6-14. Payments to states and counties from the Francis Marion National Forest, 2012 301
Table 6-15. Forest contributions to local employment and income 304
Table 6-16. Designated areas and recreational uses 308
Table 6-17. Recreation sites and their facilities 308
Table 6-18. Designated interpretative areas for the Francis Marion's heritage resources 310
Table 8-1. Waterfowl species documented during winter counts on the Francis Marion National Forest 334
Table 8-2. Volume of timber sold from the Francis Marion National Forest since 1996, and values in the last 5 years 346
Table 8-3. Percentage of forested acres within tree species categories 346
Table 9-1. ROS classes on the Francis Marion National Forest 381
Table 9-2. Recreation sites on the Forest 382
Table 9-3. Visitation of the Francis Marion and Sumter National Forest 388
Table 9-4. Preferences of South Carolinians for certain outdoor recreation activities 394
Table 9-5. Total trail mileage by type on Francis Marion 398
Table 9-6. Water-based trails on the Francis Marion National Forest 398
Table 9-7. Visual quality objectives (1996 revised Francis Marion plan) 402
Table 10-1. Miles of rights-of-ways on the Francis Marion National Forest 412
Table 11-1. Miles of national forest system roads by maintenance level 417
Table 11-2. Draft Francis Marion risk/benefit criteria 418
Table 11-3. Risk and benefit analysis of the Francis Marion National Forest road system 419
Table 11-4. Watershed condition rating indicator for the 15 6th-level watersheds based on road attributes 420
Table 11-5. Forest trail mileages by designation 422
Table 11-6. Non-recreation facilities 423
Table 11-7. Recreation facilities by location 425
Table 11-8. Recreation facilities by use 426
Table 11-9. Forest road bridges 427
Table 11-10. Forest trail bridges 427
Table 14-1. Special use authorizations 450
Table A-1. Plants of potential conservation concern on the Francis Marion National Forest 517
Table A-2. At-risk plants by species group 519

List of Figures

Figure 1-1. Vicinity map of the Francis Marion National Forest 3
Figure 2-1. Land type associations on the Francis Marion National Forest (2013) 21
Figure 2-2. Terrestrial ecosystems within the Francis Marion proclamation boundary 22
Figure 2-3. Atlantic Coastal Flatwoods Ecological Section 24
Figure 2-4. America's longleaf significant landscapes for longleaf pine conservation 25
Figure 2-5. Francis Marion National Forest subbasin and subwatershed boundaries 66

Figure 2-6. Francis Marion National Forest, summary data from watershed condition assessment 71
Figure 2-7. Francis Marion National Forest, summary data from watershed condition assessment 72
Figure 2-8. Map of Francis Marion National Forest airshed (shaded) and known sensitive air quality areas 78
Figure 2-9. Comparison of growth measures and emissions, 1990–2010 80
Figure 2-10. Emissions of fine particulate matter from prescribed fires on the Francis Marion National Forest, 2006–2011 80
Figure 2-11. Location of ozone and fine particulate matter monitoring sites used in this assessment of air quality 81
Figure 2-12. Statistical trend in ozone near the Francis Marion National Forest 82
Figure 2-13. Statistical trends in fine particulate matter ($PM_{2.5}$) near the Francis Marion National Forest for the daily (left) and annual (right) National Ambient Air Quality Standard (NAAQS) 82
Figure 2-14. Estimated Forestwide wet sulfate deposition for 1983 (top) and 2011 (bottom) have shown a significant decline 83
Figure 2-15. Trends in the average annual sulfate (left) and total nitrogen (right) wet deposition estimates (blue open circles) within the Francis Marion National Forest proclamation boundary 84
Figure 2-16. Fish consumption advisories in South Carolina 84
Figure 2-17. Measured visibility (worst visibility days) as compared to the glide path at Cape Romain National Wildlife Refuge Class I Area 86
Figure 2-18. Location of prescribed fires in 2002 and those planned for 2018 on the Francis Marion National Forest 86
Figure 2-19. Areas (yellow or red) where the average (1994–2000) atmospheric sulfur plus nitrogen deposition exceeds the soils critical loads 88
Figure 2-20. Drainage class distribution for soils within the Francis Marion National Forest 92
Figure 2-21. USGS graphs for precipitation and discharge for Turkey Creek 100
Figure 2-22. Drainage size and exceedance percentage indicates the frequency of intermittent or perennial streams in North Carolina sampling to identify source waters within the Carolina Flatwoods and Rolling Coastal Plain 105
Figure 2-23. Water level declines for selected wells in the Middendorf Aquifer near Florence, South Carolina 109
Figure 2-24. Cumulative groundwater depletion in the Coastal Plain Aquifer System of South Carolina, 1900–2008 109
Figure 2-25. Generalized geohydrologic sections of the South Carolina Coastal Plain 110
Figure 2-27. Fish consumption advisories for South Carolina in 2013 114
Figure 2-28. Estimated average suspended sediment concentration (ppm/decade) by land use and subwatershed for Francis Marion National Forest vicinity 118
Figure 2-29. Estimated erosion (tons/decade) by land use and subwatershed for Francis Marion National Forest vicinity 119
Figure 3-1. Box and whisker plots of projected mean annual temperature 139
Figure 3-2. Box and whisker plots of projected mean annual precipitation 139
Figure 3-3. Box and whisker plots of projected mean seasonal temperature 141
Figure 3-4. Box and whisker plots of projected mean seasonal precipitation 142
Figure 3-5. Wildland fire and fuels assessment analysis area 148
Figure 3-6. Presettlement fire frequency regions of the United States 151
Figure 3-7. Mean fire return interval of the Francis Marion National Forest 154
Figure 3-8. Coastal Plain fires 157
Figure 3-9. Prescribed fire burn frequency 161
Figure 3-10. Growing season prescribed fire frequency 161
Figure 3-11. Francis Marion fire regime condition class 164
Figure 3-12. Analysis area current vegetation condition class conditions 164
Figure 3-13. *Federal Register* communities-at-risk 168

Figure 3-14. Federal Register/SILVIS wildland-urban interface 171
Figure 3-15. HFRA designated wildland-urban interface 173
Figure 3-16. On-Forest values-at-risk wildland-urban interface 175
Figure 3-17. Combined wildland-urban interface 177
Figure 3-18. Prescribed fire treatment in the wildland-urban interface 179
Figure 3-19. Mechanical treatments 180
Figure 3-20. Wildland fire occurrence map 182
Figure 3-21. Analysis area wildfire summary 183
Figure 3-22. Francis Marion wildfire summary 184
Figure 3-23. Analysis area remote automated weather stations 185
Figure 3-24. Analysis area NFDRS pocket cards 187
Figure 3-25. Weather index trend through size class fire 189
Figure 3-26. Surface and crown fires 193
Figure 3-27. Potential fire behavior 196
Figure 3-28. Kernel density fire size analysis 198
Figure 3-29. Kernel density fire point analysis 199
Figure 3-30. Kernel density Coastal Plain fire size analysis 200
Figure 3-31. Kernal density attributes 202
Figure 3-32. Fire behavior attributes 203
Figure 3-33. Problem fire attributes 204
Figure 3-34. Potential problem fire area 205
Figure 3-35. Potential fire type 206
Figure 3-36. Francis Marion and Sumter National Forests budget 208
Figure 3-37. FTE decline, fiscal years 2000–2012 208
Figure 3-38. Weather indices trends 209
Figure 3-39. Wildfire potential season change 210
Figure 3-40. Time series graph of annual total precipitation from 2000–2009 with longer-term annual averages from 2000–2009 and 1980–2009 224
Figure 3-41. Time series graph of annual total precipitation and NDVI from 2000–2011 with longer-term annual averages from 2000–2011 225
Figure 3-42. Sea-level rise from 1900 to 2012 at Charleston, South Carolina (NOAA 2013) 229
Figure 3-43. Sea-level rise; change in landcover class by 2100 230
Figure 4-1. A simplified model of the greenhouse effect 234
Figure 4-2. Forest carbon distribution in the Southeaster U.S. 235
Figure 4-3. Francis Marion National Forest emissions from annual average prescribed burning 238
Figure 4-4. Total above ground live carbon stock estimates for the Francis Marion National Forest, 1968–2011 239
Figure 5-1. Range of American Chaffseed (USDI) 245
Figure 6-1. Urban-rural distribution, 2010 284
Figure 6-2. Racial composition, 2010 287
Figure 6-3. Unemployment 1990–2011 289
Figure 6-4. Employment by industry, 2011 291
Figure 6-5. 2011 State and study area employment distribution for forest-related sectors 292
Figure 8-1. Change in standing timber volume from 1993 to 2011 345
Figure 8-2. Age class distribution for the Francis Marion National Forest, April 2013 348
Figure 8-3. Uses of water for Charleston and Berkeley counties as of 2005 352
Figure 9-1. Berkeley County housing stock 368
Figure 9-2. Berkeley County population projections 368
Figure 9-3. Countywide population trends and estimates (1970–2020) 369
Figure 9-4. Land use map 369
Figure 9-5. Land use map, Berkeley County (2008) 370

Figure 9-6. Berkeley County development plans for future residential, commercial, and industrial projects 371
Figure 9-7. Urban growth boundary and growth management areas 372
Figure 9-8. Berkely County future land uses 373
Figure 9-9. Sewee Visitor Center visitation 384
Figure 9-10. Outfitter guide and special use event visitation 386
Figure 11-1. Major roads and trails on the Francis Marion National Forest 416
Figure 15-1. Wilderness areas on the Francis Marion National Forest 457
Figure 15-2. Outfitted visitor use in wilderness 458
Figure B-1. Active red-cockaded woodpecker cluster trends on FMNF since 1990 525
Figure B-2. Potential breed group trends on FMNF since 1990 525
Figure B-3. Core burn area map 526
Figure B-4. Active and inactive red-cockaded woodpecker clusters on the FMNF 527
Figure B-5. Red-cockaded woodpecker cluster density overlaid on core burn area compartments 528
Figure B-6. Map depicting the estimated urban area of Berkeley, Charleston, and Dorchester counties in 2005 529
Figure B-7. Map depicting the potential urban area of Berkeley, Charleston, and Dorchester counties in 2030 530
Figure B-8. All stands regenerated on the FMNF since 1989 (approximately 92,000 acres) 531
Figure B-9. Loblolly and mixed loblolly established on the FMNF since 1990 (approximately 31,000 acres) 532
Figure C-1. Simplified representation of the riparian–wetland–aquatic systems 533

1 Introduction

Please note: In this document we use "Forest" and "Francis Marion" synonymously with "Francis Marion National Forest". The lowercase "forest" refers to any forested area or a national forest in general.

1.1 Overview

The National Forest Management Act of 1976 requires each national forest to develop a land and resource management plan (commonly referred to as a forest plan) and amend or revise the plan every 10 to 15 years. The Francis Marion National Forest Plan was approved in 1996 and the Francis Marion is revising its Forest plan under the 2012 planning rule. Planning and revision for a national forest plan is an iterative process that includes an "assessment" (36 CFR 219.6); developing, amending, or revising a forest plan (§§ 219.7 and 219.13); and monitoring (§ 219.12).

This document summarizes the assessment stage and is designed to rapidly evaluate existing information about relevant ecological, economic, and social conditions; trends; and sustainability and their relationship to the land management plan within the context of the broader landscape. Assessments are not decision-making documents, but provide current information on select topics relevant to the plan area.

This assessment identifies and evaluates existing information relevant to the plan area for the following topics:

1. Terrestrial ecosystems, aquatic ecosystems, and watersheds
2. Air, soil, and water resources and quality
3. System drivers, including dominant ecological processes, disturbance regimes, and stressors, such as natural succession, wildland fire, invasive species, and climate change; and the ability of terrestrial and aquatic ecosystems on the plan area to adapt to change
4. Baseline assessment of carbon stocks
5. Threatened, endangered, proposed and candidate species, and potential species of conservation concern present in the plan area
6. Social, cultural, and economic conditions
7. Benefits people obtain from the national forest system planning area (ecosystem services)
8. Multiple uses and their contributions to local, regional, and national economies
9. Recreation settings, opportunities and access, and scenic character
10. Renewable and nonrenewable energy and mineral resources
11. Infrastructure, such as recreational facilities and transportation and utility corridors
12. Areas of tribal importance
13. Cultural and historic resources and uses
14. Land status and ownership, use, and access patterns
15. Existing designated areas located in the plan area including wilderness and wild and scenic rivers and potential need and opportunity for additional designated areas

1.2 Location of the Plan Area

The Francis Marion National Forest is located within Berkeley and Charleston counties in southeastern South Carolina and contains 258,942 acres (see Figure 1-1). The land the forest occupies is a triangle formed by the Santee River to the north, the Intracoastal Waterway to the east, and Lake Moultrie and the Cooper River to the west.

The Forest comprises about 12 percent of the public lands in the State. Major highways into the Forest include U.S. highways 17, 17A, 52, and state highways 41 and 45.

The Forest is within a 30-minute drive of the Charleston metropolitan area. The area surrounding the Francis Marion National Forest is predominantly urban. While few people live within the boundaries of the Francis Marion National Forest, the Francis Marion includes the communities of Awendaw, Huger, Jamestown and McClellanville. Persons per square mile in Berkeley and Charleston counties are 161.8.9 and 382.3, respectively. As a comparison, the State has 153.9 persons per square mile.

1.3 History and Distinctive Features of the Plan Area

This assessment follows two previous forest planning efforts. The one in 1985 was directed at the increased emphasis to do forest-level planning as directed in the National Forest Management Act, but our available resource information and ability to process it effectively at landscape scales was limited in comparison to the tools today.

Damage from Hurricane Hugo

Hurricane Hugo came ashore near Bull Island, South Carolina, on September 21, 1989. Estimated maximum sustained wind at landfall was 138 miles per hour. The center of the eye passed within 5 miles of the Forest. Vast areas of the forest were blown down or damaged with a storm surge of up to 20 feet. Immediate concerns after Hurricane Hugo were life and safety, which included opening roads that were hidden under the fallen trees. It became obvious that the 1985 plan was no longer going to be effective guidance.

The 1996 Francis Marion Forest Plan focused on recovery efforts from Hurricane Hugo. On the Francis Marion National Forest, 60 percent, or about 92,500 acres, of pine received heavy or moderate damage; pine age-class distribution changed primarily to the 0 to 10-year age class; and about 43 percent of the bottomland hardwood species were broken and 43 percent were uprooted.

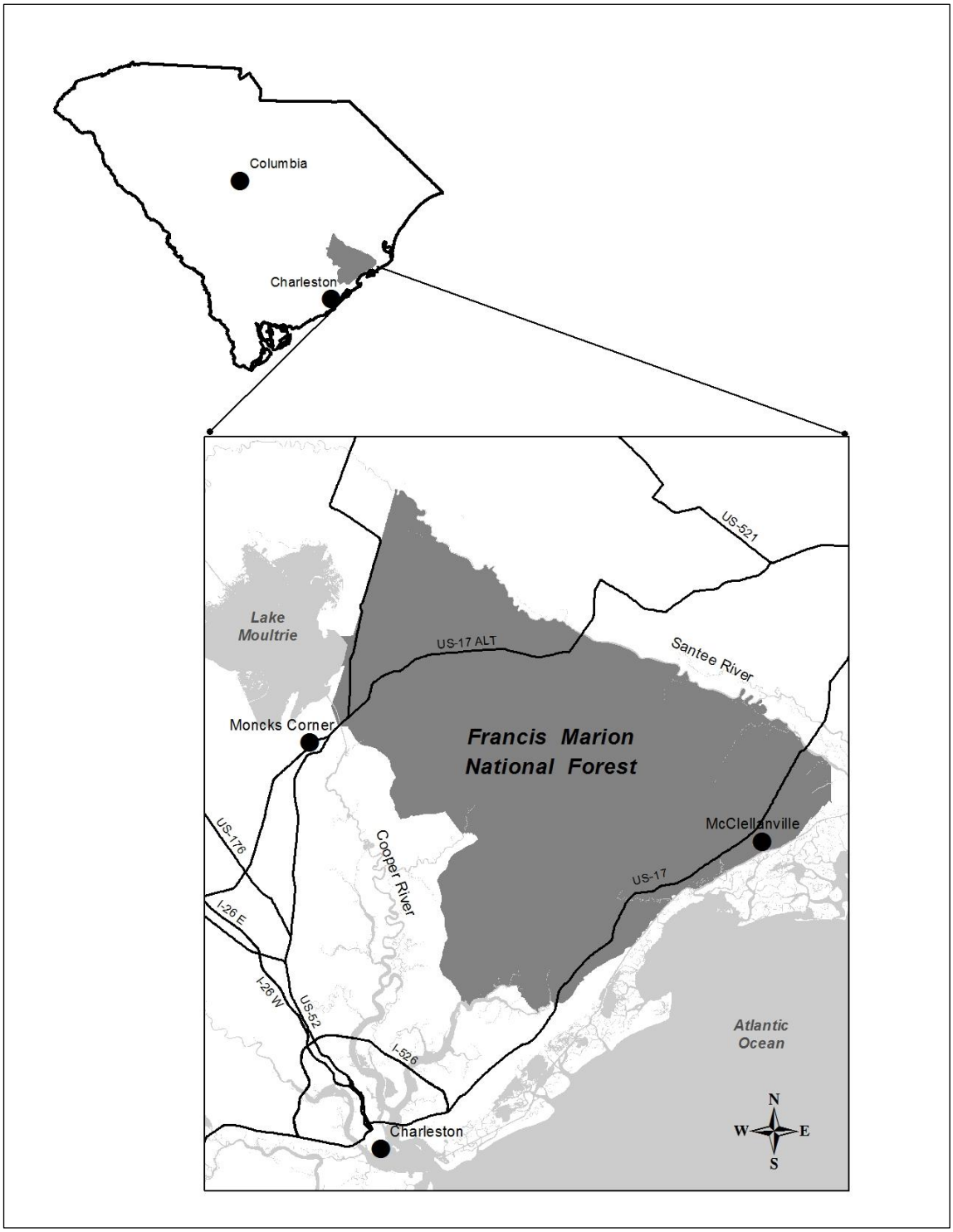


Figure 1-1. Vicinity map of the Francis Marion National Forest

After the immediate safety threats were addressed, the Forest personnel focused on recovery of the red-cockaded woodpecker, a federally endangered species. Many nesting trees with cavities were damaged, so recovery efforts focused on inserting artificial cavities. Other management efforts focused on creating foraging habitat. Today, the Francis Marion National Forest supports one of the largest populations of red-cockaded woodpecker in the world.

In 1996, the Forest staff also saw an opportunity to increase the amount of longleaf pine forest on the Francis Marion National Forest. Longleaf pine once dominated the Forest, but past management efforts had established loblolly pine.

1.4 Important Ecological Influences on the Plan Area

1.4.1 Climate

The climate of the area is humid and subtropical. Weather is highly variable. Annual rainfall averages 50 inches. Summer temperatures range from 85 to 95 °F in the afternoons and 65 to 75 °F in the early morning hours. Winter temperatures range from 55 to 65 °F in the afternoons and 40 to 50 °F in the early morning hours. The average annual temperature is 68 °F and the average humidity is 74 percent. Average annual runoff is about 10 inches per year meaning 40 inches is lost to evapotranspiration and seepage loss. Most of the area is underlain at some depth by limestone, which may have sinkholes in the more shallow areas (such as Chicken Creek and Dutart Creek Area). When limestone is within the rooting zone, productivity may be improved due to the increased available nutrients. Most upland soils are highly productive except spodisols. The productivity in wetlands for some tree species is affected due to the anaerobic soil conditions.

1.4.2 Dominant Ecosystems

The Francis Marion National Forest is within the Atlantic Coastal Plain and Flatwoods physiographic areas. The Forest's topography is relatively flat to low sloping terrain, with localized surface depressions such as connected and isolated wetlands, Carolina bays, and stream channels. Stream terraces and floodplains are most noticeable along the larger streams and rivers and tidal waters, while small tributaries range from well to poorly defined drainage patterns. Elevations range from sea level to about 60 feet. The general slope of the area is southeastward to the Atlantic Ocean. Most soils in the Forest area are highly weathered and acidic, and sands may have low nutrient status. Site productivity, however, is generally high because soils are generally deep with ample moisture available to plants due to regular rainfall.

1.4.3 Terrain

The Forest topography is relatively flat to low sloping terrain, with localized surface depressions of Carolina bays, connected and isolated wetlands, floodplains and stream channels. Extensive loblolly and longleaf pine stands are found on drier sites; hardwoods are found on moister sites, usually along streams and adjacent floodplains. The climate of the area is humid and subtropical.

1.4.4 System Drivers

Dominant ecological processes within the Forest include disturbance regimes and stressors, such as natural succession, wildland fire, invasive species, and climate change. Insects and diseases are ongoing ecosystem drivers. They have been present as long as the Forest has been in existence and continue to affect Forest composition and structure. Fire also drives ecosystem changes; it is often tied to insects and diseases that have left dead wood in the forest, increasing fuel loads and fire risk. Invasive animal and plant species have the potential to impact the ecosystem.

Forests have a substantial influence on global climate by removing CO_2 from the atmosphere and storing carbon as biomass. The 2011 estimates for the Francis Marion National Forest total 18.5 teragrams (Tg or million metric tonnes) ± 2.8 Tg of carbon. This represents about 0.04 percent of the total of approximately 45,278 Tg of carbon in forests of the coterminous United States (EPA 2012). The principal drivers of aboveground forest carbon stocks are forest growth and mortality. The primary agents for decadal and longer-scale carbon changes on the Forest are prescribed burning, wildland fire, bark beetles, and timber harvest.

1.4.5 Vegetation

Common vegetation species vary by location. The most critical factor in maintaining both longleaf pine and fire-dependent communities is the presence of relatively frequent fire (2- to 4-year cycle). Wildland-urban interface areas and smoke management concerns have limited periodic prescribed burning in certain areas of the Forest. These areas generally follow the U.S. Highway 17 and 41 corridors and a substantial area in the northern part of the Forest north and south of U.S. Highway 17A around Macedonia. Regular use of prescribed fire has led to the development of vastly different, highly desirable understory conditions in all management areas. In contrast, lack of periodic prescribed burning in some areas has increased hazardous fuel loadings in the understory. This has adversely impacted a number of fire-dependent species and ecosystems, including habitat for threatened, endangered and sensitive species.

The Francis Marion National Forest contains numerous, small, isolated forested wetland depressions dominated by pond cypress (*Taxodium ascendens*), swamp gum (*Nyssa biflora*), pond pine (*Pinus serotina*), Virginia chain fern (*Woodwardia virginica*) and often a variety of herbaceous and graminoid species including pitcher plants (*Sarracenia* spp.). These areas are embedded in other management areas and are usually very small. Some of them can contain open water habitat for at least a portion of the year. Fifty pond cypress wetland depressions were surveyed on the Forest; of those, only nine had an area in excess of 2.5 acres.

1.5 Relevance of National Forest System Lands

While national forests are important to all people of the United States, the Francis Marion National Forest is geographically located along the coast of South Carolina. Many residents from South Carolina work or recreate on the Francis Marion National Forest.

For public land managers, understanding the age distribution of the local population most likely to use the Forests can help determine whether management actions might affect some age groups more than others. It also may help highlight the needs, values, and attitudes of different age groups. For example, if a geographic location has a large retired population or soon-to-be-retired population, the needs and interests of the public may place different demands on public land managers than in an area with a larger number of minors or young adults.

1.6 Important Social and Economic Influences on the Plan Area

1.6.1 Demographics and Population Trends

The population with the eight-county area surrounding the Francis Marion National Forest steadily grew between 1980 and 2010 (+60 percent). Population growth was unevenly distributed between the study area counties, ranging from 12 percent in Orangeburg to 166 percent in Horry County. Growth in Williamsburg has been more varied relative to the other counties. Between 1980 and 2010 Williamsburg's population declined by 10 percent; most of the population loss occurred during the early 2000s.

South Carolina has gained considerable attention in recent years as a retirement destination. Between 2007 and 2011 more than 10,000 people 65 years or older moved to the State from another state or country. In-migration by older populations accounted for 6 percent of all new South Carolina residents over this 5-year period, including large numbers of retirees to counties surrounding the Forest as well. While the coastal County of Horry welcomed the greatest number of new residents 65 and older, the majority of the region's new residents 65 years or older settled in the Forest gateway counties of Berkeley, Charleston, and Dorchester.

The area surrounding the Forest is predominately urban and land development trends suggest that the area will likely become increasingly urban. Populations are forecasted to grow through 2030 and net migration is expected to play an increasing role in the region's anticipated growth. Much of this in-migration can be attributed to the areas natural and cultural amenities.

1.7 Current Contribution to Ecological, Social, and Economic Sustainability, and Multiple Uses

1.7.1 Ecological, Social, and Economic Sustainability and Multiple Uses

The Forest provides economic, social, and cultural benefits for local and regional communities and for people across the Nation. Products and services generated on national forest system lands continue to sustain traditional livelihoods; provide for subsistence uses; and provide new economic opportunities, jobs, and benefits, such as those generated through sustainable recreation and tourism, restoration activities, ecosystem services, and renewable energy. The Forests lands are also of immense social and cultural importance, enhancing quality of life; sustaining scenic, historic, and culturally important landscapes; sustaining traditional life ways; and providing places to engage in outdoor recreation, improve physical and mental health, and reconnect with the land.

The current Forest plan provides for multiple uses, including outdoor recreation, timber, watershed, wildlife and fish. To meet multiple use requirements and provide for integrated resource management, responsible officials consider a range of uses, values, and benefits that may be important to communities and relevant to the unit. These include outdoor recreation, range, timber, water, wildlife, wilderness, energy, minerals, and ecosystem services; as well as issues such as sustainable infrastructure needs; opportunities to work with neighboring landowners; habitat conditions needed for hunting, fishing, subsistence; public drinking water supplies; and reasonably foreseeable risks to sustainability.

The Francis Marion contributes to the economic sustainability of forest-dependent communities by cultivating a robust tourism and recreation industry and by continuing to support economic activity in local logging and wood manufacturing industries. Understanding how these forest-related industries benefit from the Forest's resources is essential to understanding the consequences of changes in Forest management. As part of the assessment process Forest specialists identified how the Forest's multiple uses (timber, watershed, fish and wildlife, and outdoor recreation), infrastructure, and cultural and historic resources contribute to the viability of the local economy.

The Francis Marion contributes to social sustainability by providing opportunities for families and friends to recreate in an outdoor setting. Management activities within the Forest has some limited lifestyle impacts to the local communities, due to the integration of family, work, outdoor recreation, and place and the quality of life for residents. At the public meeting, participants indicated that the Francis Marion was important, because it provided opportunities to get away from the hectic pace of city life, to find peace and solitude, and to enjoy the natural environment in a number of ways, such picnicking, kayaking, fishing, hunting and bird watching.

Communities located near and individuals living close to the Forest place a high value on the recreational experiences. Activities such as hunting, fishing, hiking, kayaking, wildlife viewing, berry picking, and bird watching are outdoor recreation activities enjoyed by people when they are not working. The outdoor activities can be family gatherings or simply reinforce social bonds. The rivers and trails are all important because they enable the resident's recreation lifestyles. After work, on weekends, or on vacations, people engage in outdoor recreation activities. The outdoor recreation activities and the perceived tradeoffs to pursue them are important characteristics of lifestyles in these neighboring communities. Concerns over increased conflicts with other Forest visitors could impact people's recreation use pattern. At the public meetings, some concerns about the impacts of dog hunting on other users were mentioned. On the other hand, the Francis Marion National Forest is one of two locations in the state where hunting deer with dogs is allowed.

The rapid growth in the area is leading to changes in values, beliefs, and attitudes along with changes in the demographics with the area. While the Lowcountry of South Carolina has a shared developmental and cultural history, the influx of retirees and other people from outside the State bring a different set of values, beliefs, and attitudes that have profound impacts on how people use the Forest and view management activities.

The rapid population growth will also impact ecological sustainability. Urbanization of private forest land will have indirect impacts on national forest management and the ability of the natural resources to provide goods and services. When natural ecosystems become tightly linked to human settlements and economic and social forces, the ecosystems become increasingly vulnerable to disturbances from which it was previously able to recover. Conversion of private forest lands to altered, largely-urban areas impact ecosystem integrity and its ability to recover from natural disasters, which in turn affects the ecosystem's ability to provide goods and services, which can result in losses in timber products, water availability and quality, native habitats, and air quality. The rapidly growing population will increase pressure on aging sewer systems, increase storm-water runoff into stream systems, and create an intensified heat-island effect that will have indirect effects on the key ecosystem services that the Forest currently provides.

1.7.2 Key Ecosystem Services and How Communities Benefit

1.7.2.1 Provisioning Services

The Forest is capable of providing each of these "provisioning services" at varying levels to the local and national communities. For example, clean air is ensured through compliance with regulatory agencies, with spatial and temporal thresholds regularly assigned to standards. Fresh water is ensured through managing watershed lands for multiple uses while recognizing domestic supply needs.

Renewable energy resources include wood biomass (fiber), and wind, solar, geothermal and hydroelectric energy. On the Forest, wood biomass has been sold as a product and development of wood biomass, a byproduct of timber operations, may be feasible. An occasional solar panel is used to power a remote site and firewood for personal use is commonly collected and used as a heat source. No nonrenewable energy is being produced on the Forest.

Nonrenewable energy resources consist of oil, gas, and coal. There are no known oil or coal deposits on the Forest. No mineral activity is occurring on the Forest. No gold, silver or copper resources are known on the Francis Marion. Two mineral resources, limestone and sand, occur within the boundaries of the Forest, but there are no active leases or permits.

1.7.2.2 Regulating Services

Forests substantially mitigate the climate effects of increasing atmospheric CO_2 concentrations by removing carbon from the atmosphere and storing it as biomass. U.S. forests offset about 10 to 20 percent of U.S fossil fuel emissions. Available information suggests that carbon stocks of the Forest have been increasing over the last several decades as they recover from extensive agriculture in the late 19th and early 20th centuries, though the future trajectory of carbon stocks on the Forest is uncertain.

The current strategy of the Forest is to ensure that its management actions continue to provide water quantity and quality that support recreational uses, healthy riparian and aquatic habitats, the stability and effective functioning of stream channels, and the ability to route flood flows. Additionally, in filtering and buffering, the Forests' soils act as a filter to protect the quality of water, air, and other resources. Though past agricultural practices have impacted soil functions through compaction, erosion, and loss of organic matter, the Forest has substantially decreased these types of effects through management practices. These management practices, coupled with current soil restoration activities, should lead to an increased capacity of the soils to provide multiple uses and ecosystem services in perpetuity, including storage, soil stabilization, and flood control.

Human health, particularly risk of exposure to many infectious diseases, may depend on the maintenance of biodiversity in natural ecosystems. Biodiversity is the number, abundance, and composition of genotypes, populations, species, functional types, communities, and landscape units. Evidence is accumulating that greater wildlife species richness may decrease the spread of wildlife pathogens to humans. The Forest is committed to maintaining biodiversity.

1.7.2.3 Supporting Services

Major ecosystem services are supported by the direct interactions between plants and animals, such as herbivory, pollination, and seed dispersal. Biodiversity strongly influences the provision of these ecosystem services and therefore human well-being. The Forest recognizes the full economic benefits of wild pollinators and seed dispersal as important functions of the ecosystem; therefore, management actions are sensitive to maintaining biodiversity.

Regarding soil formation and nutrient cycling, the emphasis of soil management focuses on long-term soil quality and ecological function. The two objectives of this emphasis adhered to by the Forest are to maintain or restore soil quality on Forest lands and manage resource uses and soil resources on Forest lands to sustain ecological processes and function so that desired ecosystem services are provided in perpetuity.

1.7.2.4 Cultural Services

Across the Forests, nature provides opportunities for numerous recreational experiences, including biking, camping, hiking, big game hunting, fishing and boating. Visitors can travel the intracoastal waterway, visit interpretive and educational sites that reveal the rich history of the region, reach remote areas on foot or in a vehicle, and view wildlife in natural surroundings. Visitors who participate in these activities generally visit adjacent communities and contribute to those economies in various ways.

Travel and tourism consists of sectors that provide goods and services to visitors of the local economy, as well as to the local population. These industries are retail trade; passenger transportation; arts, entertainment, and recreation; and accommodation and food.

There are hundreds of historic properties across the plan area; these vary by resource class, location, age, and condition. Taken as a whole, historic properties across the plan area are in fair condition, and Forest's managers are dedicated to their conservation.

Additionally, particular landscape features and places connect the traditions and history of the past with the identity and values of the present for members of the various tribes interested in the Forests, including the Catawba Indian Nation. The Forests respect these cultural values and works with tribal contacts as appropriate.

1.8 Risk Factors and Uncertainty

The management direction (goals, objectives, desired conditions, standards and guidelines) in the Forest plan assumes that our desired outcomes will remain so for at least a decade. In addition, any unplanned natural or human caused events will be at a scale small enough to not be a significant threat to achieving the planned objectives. The Forest relies predominately on its monitoring reporting to assess changing conditions and new risks as they develop, and adapt management direction as necessary to reach the Forest plan's desired outcomes.

1.9 Best Available Science

In the preparation of this assessment of the Forest plan, best available science was used to update some of the information. Forest personnel worked with individuals, university and research personnel, non-profit organizations and county, state and Federal agencies to identify existing, relevant, accurate and reliable information to inform the findings in the assessment. These contacts included individual telephone calls or emails or information gathered at public meetings. Other sources of information included the annual monitoring reports and public input gathered using a combination of public meetings and on-line canvases.

1.10 Public Involvement

To date, the Forest has hosted four community conversations starting in October 2012.

- The first two public meetings of October 25 and November 15, 2012, used a "World Café" meeting format.
- The third public meeting was held on February 26, 2013, with a focus on sustainable recreation and benefits that people get from the Forest. This effort included using an on-line collaborative website to gather public input for 60 days.
- The fourth community conversation, a forum on ecological sustainability held on August 6, 2013, was co-sponsored by the Coastal Conservation League and The Nature Conservancy. This meeting used a combination of presentation and break-out groups to create an understanding of terminology and discuss the plan revision process and public involvement.

Notes from each public meeting are posted on the public website at http://www.fs.usda.gov/scnfs. Highlights from the meetings are summarized below.

1.10.1 Fall 2012 Public Meetings

1.10.1.1 Emerging Themes from 2012 Fall Public Meetings

1) Sharing resources with partners and integrating into other planning efforts for efficiency is important to stakeholders. One example is the Sewee Longleaf Conservation Cooperative, currently under the leadership of the The Nature Conservancy, who is starting a landscape-scale planning process for longleaf restoration. Another example is the planning for the East Coast Greenways Project. Increasing coordination should decrease time and costs for planning and improve future outcomes.

2) Outreach should include presenting and discussing information at stakeholder sponsored meetings rather than relying solely on stakeholders to attend Forest Service sponsored meetings. Partners can share information through their networks if they are provided information in a timely manner. This includes local community meetings, such as city councils, churches, and schools. The local underserved community or minorities may not know that they are stakeholders in national forest management and outreach to them in their own supporting environments could increase their participation in Forestwide planning.

3) Many of the nature features on the Forest are unique in the local and regional context. Dozens of places have been identified with special features that are unique to the Forest. Nature-based experiences and the supporting recreational facilities are important for stakeholders.

4) Stakeholder interaction with the Forest environment appears to improve their quality of life, health, and well-being. Stakeholders cited important aspects of improving their livelihood, such as getting away from congestion (reducing stress), silence, exercising, and learning about the environment.

5) Among the major challenges are: The management of the wildland-urban interface zone and, specifically the restrictions on prescribed fire to maintain or restore the fire-adapted ecosystems; the maintenance of infrastructure, specifically trails and roads; the invasion of nonnative species, such as the degradation of ecosystems caused by feral hogs; and more challenges as listed in the responses.

1.10.1.2 Emerging Themes from Sustainable Recreation and Ecosystem Services (February 26, 2013)

Forest as a Provider of Benefits. Of the benefits identified by all participants, four primary themes emerged:

1. The Forest benefits the public by providing diverse outdoor recreation experiences set within beautiful, natural scenery. In particular, the Forest is uniquely suited to provide trail, wildlife viewing, and hunting opportunities.

2. The Forest benefits the public by providing green space which can enhance quality of life through spiritual renewal, physical exercise, mental "escapes," and the opportunity for quiet reflection.

3. The Forest benefits the public by providing a large area of land for birds and wildlife to thrive. The varied ecosystems of the Forest support a diversity of birds and wildlife, including both rare, native species and migratory species such as neo-tropical birds.

4. The Forest benefits the public by reflecting the Lowcountry heritage of South Carolina, as well as by protecting historical sites of significance and allowing for the continuation of traditional uses.

Forest as a Unique Contributor. Participants identified that the Francis Marion National Forest was the only place they could go to do, see, and experience a variety of features. Of the unique roles and attributes identified by all participants, four primary themes emerged:

1. The Forest is significant because it provides approximately 250,000 acres of natural habitat for birds and wildlife, including the endangered red-cockaded woodpecker.

2. The Forest is significant because it has great ecological diversity, including longleaf pine, Carolina bay and cypress swamp communities.

3. The Forest is unique because it can provide visitors with a sense of remoteness. The Forest provides a convenient and free place to "get away from it all," thus being able to escape the noise, lights, and congestion of neighboring metropolitan areas.

4. The Forest offers recreation settings, activities, and infrastructure which, when combined, create a unique recreational experience that cannot be found elsewhere. Particularly, paddling trails, motorized trails, and hiking/walking trails are most unique to the Forest.

Forest Favorite Places. Participants identified 125 favorite places both on and off the Francis Marion National Forest. Cape Romain National Wildlife Refuge, the Palmetto Trail, I'on Swamp Trail, and Wambaw Creek were among the most frequently mentioned places. In reviewing all favorite places, three characteristics of primary importance emerged:

1. Favorite places provide recreation infrastructure which facilitates certain types of uses. Nearly 25 percent of participants noted their favorite place included a trail.

2. Favorite places offer beautiful natural settings and scenic vistas, particularly of the Longleaf Pine Ecosystem and water bodies.

3. Favorite places allow access to water, including the Intracoastal Waterway, inland ponds, and many rivers and creeks.

Forest Improvements. Participants identified many ways in which they felt their connection to the Francis Marion National Forest could be improved. According to most participants, a higher quality of experience and more frequent use could be achieved if the following areas were improved: Recreation infrastructure and management, hunting, visitor information, signage and interpretation, fire, vegetation, and wildlife management.

1.10.1.3 Ecological Sustainability Forum

The synopsis of comments from the evaluation of the forum include:

- Overall, respondents felt the Forest Service planning process was well-explained, even for those who did not have prior knowledge of the Forest plan.
- Majority of respondents felt meeting and greeting stakeholders and networking were the most valuable aspects of the forum.
- Majority of the respondents felt that sustainability issues were too deep and wanted more time in breakout sessions.
- Additionally, the majority of respondents wanted more clarification on what input was desired from the audience and wanted more interaction.
- Prevailing topics respondents wanted to see covered in future forums were social and economic issues and other wildlife studies to include wildlife criteria and other management considerations and wildlife threatened or endangered species.

1.11 Summary of the Assessment

On December 18 1995, the Revised Land and Resource Management Plan for the Francis Marion National Forest (Forest plan) was signed. Several primary post-Hugo concerns drove the 1996 plan revision in response to the drastically changed conditions including activities to address the fuel hazard/fire potential that existed, recovery of the red-cockaded woodpecker habitat and replacement of

lost colonies. Connected to these was an emphasis to identify and recover suitable areas to longleaf pine with regular prescribed burning in the future.

An assessment was completed to identify existing conditions of resources and trends changes that have occurred since implementation of the 1996 plan.

1.11.1 Timber Harvest

Harvest levels in the 1996 Forest plan are sustainable. There is still a strong, competitive timber market; and there are new wood markets emerging due to changes in technology. For instance, logging debris and small-diameter materials may provide wood biomass.

1.11.2 Impacts on Forest Revenues to Counties

Counties receive 25 percent of the receipts from the sale of timber, recreation fees, and royalties from mineral leasing on Federal lands within the county. Most receipts come from the sale of timber.

1.11.3 Protection of At-risk Species

Many of the "at-risk" species identified in the assessment are dependent on frequent fire (2- to 4-year-fire-return interval). The Wando area has the highest density of at-risk species and is at the greatest risk of impacts from urban sprawl. The Francis Marion is home to the one of largest populations of red-cockaded woodpeckers in the world. More recently, critical habitat for frosted flatwoods salamander was identified on the Forest in the Wando area. The Wando area is under pressure from urban sprawl from Charleston.

1.11.4 Wildlife Habitat

The Longleaf Pine Ecosystem is one of the most diverse ecosystems in the world. This ecosystem provides habitat for many at-risk plants and animals that depend on a frequent fire return interval (2 to 4 years).

1.11.5 Resource Potential

National visitor use monitoring shows an increased demand for dispersed recreation opportunities, such as photographing wildlife, nature viewing, hiking, horseback riding, mountain biking, and water-related activities.

Hunting on the Forest continues to be popular. However, there is a shift toward hunting big game rather than small game. The demand for fishing is increasing faster than the demand for hunting.

1.11.6 Acres Classified as Wetlands

The 1985 plan classified 37,650 acres as wetlands; in the 1996 Forest plan about 145,000 acres are classified as potential wetlands. Although the definition the Forest uses for wetlands has remained the same since the last planning period, the method of inventory, or wetland delineation, has changed. One potential wetland inventory is based on hydric soils and another method used ecological classification. These two methodologies produced similar estimates of 145,000 acres and 148,000 acres, respectively.

1.12 What is the Next Step?

The assessment findings will provide the basis for the "need for change" statements used in the need for change document. However, the need for change will identify potential changes in Forest plan direction. These changes are related to:

- Analysis tools such as LiDAR, GIS, and other capabilities have grown since 1996. These new analysis tools provide us additional information as we look at what has been accomplished and what has changed over the last 15 to 20 years.
- Since 1996, emerging technologies have created new markets, such as the potential to sell wood biomass as a renewable energy source. The State of South Carolina is looking into renewable energy opportunities, such as off-shore wind development.
- Projected sea-level rise and population increases. Consumptive water uses on the Forest, such as municipal or industrial withdrawals are limited, but dams limit the recharge of freshwater into areas where there are tidal changes. Sea-level rise has the potential to increase salinity within the area influenced by tidal changes.
- More recently the introduction and spread of nonnative invasive species impact management of the Francis Marion National Forest. For instance, feral hogs have spread throughout the Francis Marion and often damage plantings of longleaf pine seedlings.
- Changes in law, policy, or regulation affect the implementation of management activities. For instance the release of the 2012 planning rule provides direction on required forest plan components.

2 Assessing the Ecological Sustainability and Diversity of Plant and Animal Communities

2.1 Terrestrial Ecosystems, Aquatic Ecosystems, and Watersheds

2.1.1 Terrestrial Ecosystems

2.1.1.1 Summary of Key Findings

Longleaf Pine Ecosystems

►**Ecological classification and modeling conducted in 2013 predicts that longleaf pine-dominated ecosystems once occurred on 56 percent of our Forest (144,492 acres), including 21 percent (53,857 acres) as upland longleaf woodlands and 35 percent (90,735 acres) as wet pine savannas and flatwoods.** Although we have met our short-term objective in the 1996 revised Forest plan for longleaf pine-dominated forests (44,700 acres), we have not met our long-term objective (53,500 acres). In the 1996 revised Forest plan, the Forest Service estimated the range of longleaf pine at between 37,000 and 75,000 acres, and contained a goal for longleaf expansion of 21 percent. Based on dominant forest types in the Forest Service vegetation database in 2013, 49,102 acres are dominated by longleaf pine or mixtures with loblolly pine (19 percent of the Forest).

►**Lack of frequent (1 to 3 year) prescribed fire is the primary threat to longleaf-associated ecosystems and at-risk species on the Forest, and throughout the range of longleaf pine, particularly at the wildland urban interface.** Between 2005 and 2012, 36 percent of our Upland Longleaf and 15 percent of our Wet Pine Savanna ecosystems were prescribed burned at a frequency consistent with the ecological role of fire (at least 3 times during that time frame, or a 2.7-year frequency). Between 2005 and 2012, we prescribed burned 80,397 acres on at least a 3-year frequency (31 percent of our forested acres). Monitoring data collected with species and ecosystem experts in 2012 and 2013 suggest that designated botanical areas and rare plant species populations have declined since 1996 due to lack of frequent prescribed fire; those in greatest decline occur at the wildland urban interfaces.

►**Open park-like savanna and woodland conditions, including two-tiered or uneven-aged canopy structures and diverse herbaceous understories, are key ecosystem characteristics of Longleaf Pine Ecosystems.** Overly dense canopies of loblolly pine and successional woody and shrub vegetation, which both shade out the understory and draw down the water table, threaten several high quality wet pine savannas, native ecosystems, and at-risk species on the Forest. The 1996 Forest plan did not contain objectives for maintaining savanna or woodland structural classes, nor herbaceous understory conditions. Both Natureserve (2012) and the Longleaf Partnership Council (2013) describe longleaf pine canopy structure as two tiered or uneven-aged, with longleaf pine basal area of 40 to 70 square feet (25 to 60 percent cover) and a lower range down to 10 square feet (5 to 25 percent cover) for wet savanna communities. Methods for managing timber in the 1996 Forest plan were even-aged, particularly within 0.5 mile of red-cockaded woodpecker clusters and on soils classified as very poorly, or poorly drained due to operational constraints. Thirty-four percent of our longleaf ecosystems have open canopies (woodland, savanna, or grassland) based on analysis of LiDAR data.

►**Several studies of longleaf pine-associated vegetation have concluded that Longleaf Pine Woodlands and Savannas are among the most species rich ecosystems in North America, and they are also among the most endangered.** Rangewide threats to longleaf ecosystems, based on America's Longleaf Conservation Plan (2009), are fragmentation, unsustainable harvest, conversion to other land uses and vegetation types, invasive species, and exclusion of natural fire regimes. Other threats on the Forest include displacement and rutting of soil, lack of frequent prescribed fire, overly dense canopy cover, and an over-abundance of woody hardwood or shrub successional vegetation.

►**Based on the longleaf assessment conducted in 2010 with the South Carolina Nature Conservancy, the majority (53 percent) of our existing and restorable longleaf pine ecosystems (47,086 acres) are in the "restore all condition class."**

►**Ecological departure matrices (Low et al. 2010) used to compare forest structural data derived from GIS and LiDAR with LANDFIRE biophysical settings models, suggests that landscapes on the Francis Marion deviate moderately from reference conditions in regard to structure, and the National Forest has relatively low levels of late-successional open conditions.**

►**Loblolly pine or loblolly pine/hardwood forests currently occupy 104,376 acres including 25,673 acres on upland longleaf sites, 50,760 acres on wet pine savanna sites, and 23,310 acres on nonriverine swamp sites.** Both longleaf pine and fire were discouraged by turn-of-the-century forest management practices. According to historic records, the percentage of loblolly pine-dominated forest has increased by upwards of 16 percent since the Forest was acquired in 1936. Natural community and ecosystem descriptions by State heritage programs and by Natureserve suggest that loblolly pine was most common as a component of bottomland hardwood and nonriverine swamp forest ecosystems historically.

►**Possible old growth forests, dominated by longleaf pine or mixtures (>100 years and those on unsuitable lands) increased from 3,583 acres in 1996 to 3,668 acres in 2013 (which represents 2.5 percent of the total acres predicted for the two ecosystems combined in 2013).** Possible old growth forest addressed in the 1996 FEIS included 527 acres older than 100 years in age, and 3,141 acres on lands unsuitable for timber production. In 2013 the acreage in possible old growth longleaf using even-aged age criteria alone from FSVEG (≥100 years in age, or ≤ age year 1913), includes 3,668 acres and remains at 1.4 percent of the total potential longleaf acreage (upland and wet pine savanna and flatwoods ecosystems combined). The analysis of old growth conditions in both 1996 and in 2013, does not consider old growth condition, nor the distribution of possible old growth among small, medium, or large patches sizes.

►**Management area 26 does not reflect our landscapes most suited for maintaining and restoring longleaf ecosystems.** In the 1996 Forest plan, the Forest emphasized longleaf pine ecosystem restoration in management area 26 (sandy ridges and sideslopes) and contained a standard to prescribed burn this management area on a 2- to 3-year rotation. Although the majority of our upland longleaf ecosystems occur in in this management area, the majority of our wet pine savannas occur in management area 28 (flatwoods and loamy ridges), where loblolly pine forests were emphasized. Because of smoke management concerns in the wildland-urban interface less than half (34 percent) of management area 26 has been burned on at least a 3-year rotation (from 2005 to 2012).

►**Nonnative invasive species have increased to threaten all ecological systems on the Forest, and were not addressed in the 1996 Revised Plan.** Several nonnative invasive species threaten Longleaf Pine Ecosystems, most notably cogongrass, Japanese climbing fern, and feral hogs. On the Francis Marion, 32 nonnative invasive plants have been documented and since 2002, Japanese climbing fern, which has the potential to disrupt natural fire regimes, has been documented from over 3,000 occurrences. Cogongrass, a federally-listed noxious weed discovered on the Forest in 2007, remains at controllable levels (one site). Other nonnative invasive plant species, based on lists maintained by the South Carolina and Southeast Exotic Pest Plant Councils, include State aquatic nuisance species Chinese tallow and common reed (*Phragmites* spp.), Japanese honeysuckle, Chinese privet, Japanese stiltgrass, Sericea and bicolor lespedeza, tall fescue, mimosa, small carpet grass, Chinaberry, kudzu, tree-of-heaven, and Chinese wisteria. Since 2001, the Forest has selectively and chemically treated over 1,500 acres for nonnative invasive plants.

►**Landscape connectivity is important for facilitating gene flow, mitigating effects of climate change, promoting terrestrial and aquatic lifecycles for species, and for maintaining associated fire-adapted and dependent plant and animal habitats, communities, and ecosystems.**

Hardwood Forests

►**Upland hardwood forests (dry-mesic oak and mesic slope forests), occurred on less than 1 percent of the forest historically based on ecological modeling conducted in 2013.** The 1996 revised Forest plan contained an objective to have 20 percent of forested acres typed and managed as potential hard mast-producing hardwoods in the next 10 years, with an emphasis on management area 27. Analysis of dominant forest types using the FSVEG database in 2013 shows only 6.6 percent of our forest types typed with oak. Oak species can occur as a component of several of our native ecosystems, but are often not common enough to be detected in FSVEG as dominants or co-dominants within stands.

►**Mesic slope forests dominated by American beech occur in portions of the Huger Creek drainage basin and in proximity to the Santee River (Everett 2012; McMillan et al. 2001; Porcher 1995).** Some of these uncommon forests associated with high calcium and limestone or phosphate deposits were recognized in the 1996 revised Forest plan as designated botanical areas, and monitoring suggests they are threatened by dense canopies of loblolly pine, prescribed fire that is too frequent or intense, nonnative invasive plant species, and feral hogs.

►**Forested wetlands occur on 118,730 acres or 45.8 percent of the Forest, of which nonriverine swamp forests are the most abundant.** The 1996 revised plan addressed swamp forests dominated by bald cypress and swamp tupelo, “brush” vegetation, and bottomland hardwoods, without consideration of landscape position, riparian function, structure, or disturbance dynamics. Vegetation in nonriverine swamp forests, the second most abundant ecosystem on the forest, can range from a wetter group with bald or pond cypress and swamp gum, to a drier group with bottomland oak species and loblolly pine—sometimes occurring with evergreen bay and pond pine vegetation, depending on fire frequency and hydrology. More work is needed on refinements of nonriverine swamp forest vegetation and disturbance dynamics.

►**Ecological departure rankings (Low 2010) suggest that the structure of the majority of our forested wetlands are moderately departed from reference conditions.** Small blackwater river and stream floodplain forests, and possibly nonriverine swamp forests have much fewer late-successional open forests and more late-successional closed forests compared to reference

conditions. Large river floodplain forests had a much higher percentage of late-successional closed forests and fewer early-successional forests than predicted.

►The majority of our possible old growth (stands aged >100 years in FSVEG) in 2013 occurs as forested wetlands, including bald cypress and swamp tupelo forests (13,276 acres), bottomland hardwood forests (6,557 acres), and sweetbay-swamp tupelo-red maple or pond pine and mixtures (5,030 acres).

Depression Ponds, Carolina Bays, Pocossins, and Seepage Slopes

►Many of the Carolina bays and depression ponds on the Francis Marion National Forest are imbedded within upland pine terraces (Cordesville, Pamlico, and Princess Anne Marine Terraces) where prescribed fire would have occurred frequently across the landscape.

►Depression ponds and Carolina bays contain some of our highest biological diversity, specifically those dominated by pond cypress savannas and herbaceous meadow vegetation. Studies have shown that highest levels of plant species richness occur in the non-hydric ecotone of Carolina bays and depression ponds, where they intersect with fire-maintained upland longleaf and wet pine savannas. Hydrology, prescribed fire, and landscape setting are drivers in determining vegetation dynamics (DeSteven and Harrison 2006).

►Many Carolina bays, depression ponds, and seepage slopes on the Francis Marion National Forest are threatened by feral hogs, successional vegetation, and lack of frequent prescribed fire, particularly at pond ecotones and sand rims; some are threatened by illegal all-terrain vehicle traffic and illegal plant collecting (Everett 2012; Glitzenstein 2012).

Maritime Forests and Saltwater Marsh

►Maritime forests and saltwater marsh are relatively rare but important ecosystems on the forest, and several new tracks of land containing maritime fringe and salt marsh have been acquired since 1996 "Charleywood Plantation". Ecological departure rankings suggest that our maritime forests are moderately departed structurally from reference conditions; we have higher levels of early succession and in mid-closed conditions, and lower levels of late-successional closed conditions, compared to reference conditions. Many of our maritime fringe forests are threatened by past management practices which included ditching and diking for the production of rice (Porcher 2005), planting of loblolly pine, nonnative invasive species, and hurricanes. In the future, they are the most likely to be threatened by sea-level rise and climate change.

2.1.1.2 Changing Conditions

Ecological Integrity and Ecosystem Diversity

This section of the assessment is intended to provide information to formulate plan components to maintain or restore ecological integrity and ecosystem diversity.

Ecosystem Diversity

In 2009, the Forest Service entered into a national memorandum of understanding with Natureserve to cooperate in the development and application of ecological classification and mapping standards, and in biodiversity conservation information. Several state classifications of natural vegetation are available and were consulted in development of a revised ecosystem framework and at-risk species groups including those for South Carolina (Nelson 1986), North Carolina (1990), and Georgia (Edwards et al. 2013). The Natureserve Ecological System Framework (2012) is a mid-scale ecosystem classification which is based on the International

Vegetation Classification System, and forms the basis of LANDIFRE (Landscape Fire and Resource Management Planning Tools) and Southeast Gap Analysis Project collaborative vegetation mapping tools. Natureserve's ecosystem classification is informed by previous vegetation classification efforts, and incorporates physiognomy, biogeography, and hydrology into one classification, representing the next step in ecological classification.

Geographic Information Systems (GIS) Data used in the Analysis

The following are some of the digital data sources considered in the analysis of ecological integrity of terrestrial ecosystems on the Francis Marion National Forest.

- FS VEG: The Forest Service internal 'stands' database. Stands are typically 10 acres or larger in scale; vegetation is relatively similar in condition and age, and is mapped and described in terms of dominant tree species, condition, and age; recent data on unmanaged stands is limited;
- Ecological modeling (1st approximation): LiDAR Hillshade, 5-foot Digital Elevation Terrain Models, ecological systems classified from vegetation field data, Carolina Vegetation Survey (CVS) vegetation plot data, Natural Resources Conservation Service (NRCS)-derived soils;
- Threatened, endangered, and rare species occurrence data (Forest Service internal databases, State Heritage biological conservation database);
- Invasive plant species infestations (Forest Service internal databases). These databases includes a limited number of areas that have been surveyed for invasive plants on the Forest;
- Prescribed fire history, 2005 to 2012 (Forest Service internal databases);
- Canopy cover derived from LiDAR Hillshade (Forest Service internal databases);
- Rare and natural community occurrence data, including natural areas, rare communities tracked by the South Carolina Heritage Program, and rare communities acquired through various survey efforts;
- Ecological subregions: Sections and subsections of the conterminous United States (1:3,500,000) (CD-ROM).

Ecological Classification

The national framework of ecological units developed by the USDA Forest Service in 1993 (Cleland et al. 1997) specifies the consideration of landform, soils or geology, and potential natural vegetation in the classification of ecological units and ecological potential at various scales. Those scales most relevant to forest planning are the landtype association and the landtype scale.

Ecological classification system was used in development of land allocation options for the 1996 revised Forest plan (Final Environmental Impact Statement, 1996, pages II-2-3 and appendix B) based on soil drainage and texture, landform, geology, and dominant tree species to define ecological units. Given the new information and technology available since 1996, a revised ecological classification units for the Francis Marion National Forest, at both the landtype association level (LTA), and the landtype (LT) level were developed in 2013 (Simon and Hayden 2013). This information will be referred to throughout the analysis. Landtype associations for the Francis Marion National Forest include the Cordesville, Pamlico, Princess Anne, and Talbot Marine Terraces, and the Santee River and Major Tributaries (Figure 2-1).

At the finer scale of landtype and landtype phase, Simon and Hayden (2013) modeled ecological systems and acreage using the Natureserve Ecosystem framework. Figure 2-2 shows the acreage of each ecosystem predicted based on a first draft of ecological modeling efforts and based on sampling of vegetation at over 1,000 locations (Simon and Hayden 2013). Detailed descriptions of each are available on request (Natureserve 2012), and will be referred to throughout this document. Descriptions of structure and disturbance regimes for ecological systems are addressed in the relevant biophysical setting descriptions from LANDFIRE (www.landfire.gov/).

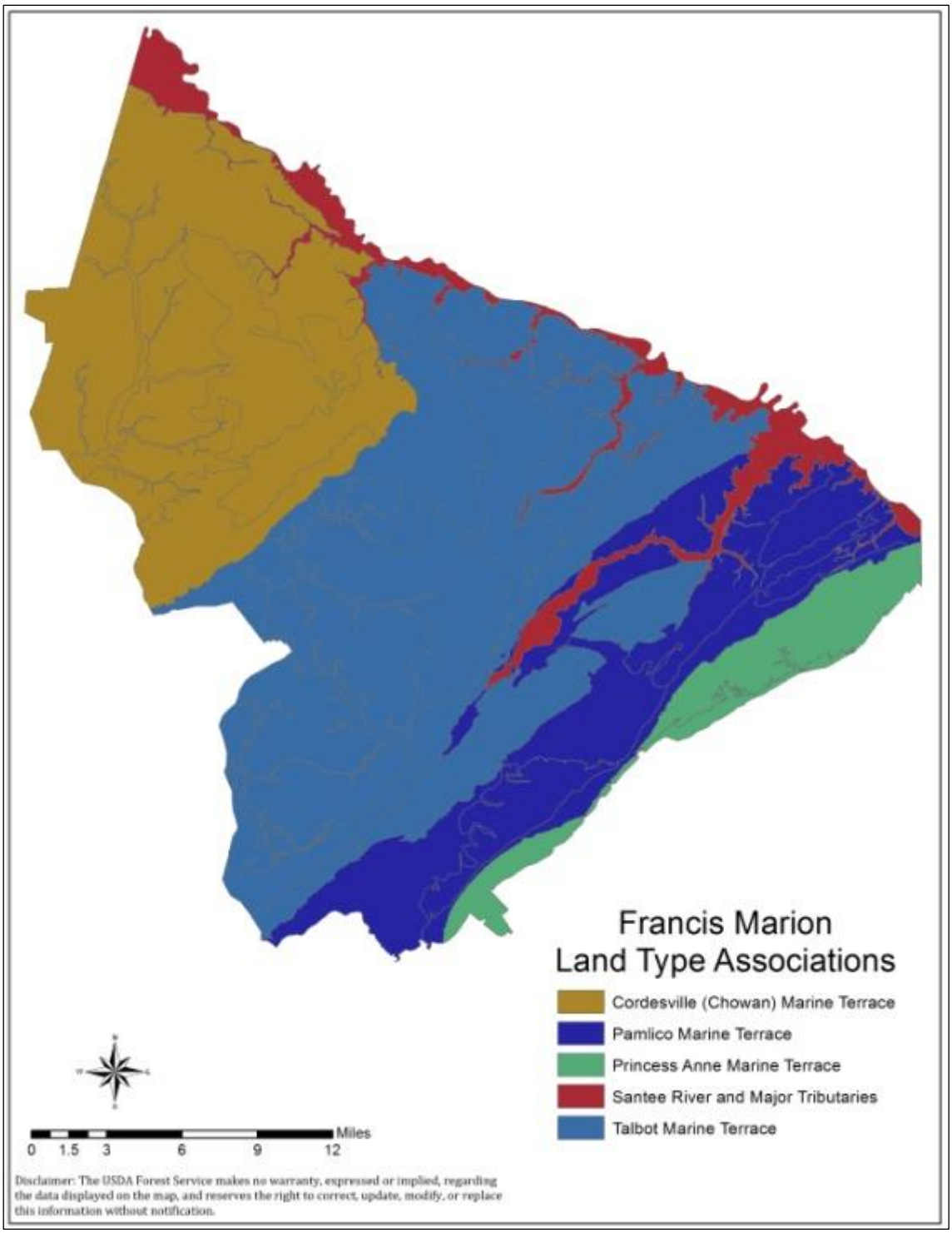


Figure 2-1. Land type associations on the Francis Marion National Forest (2013)

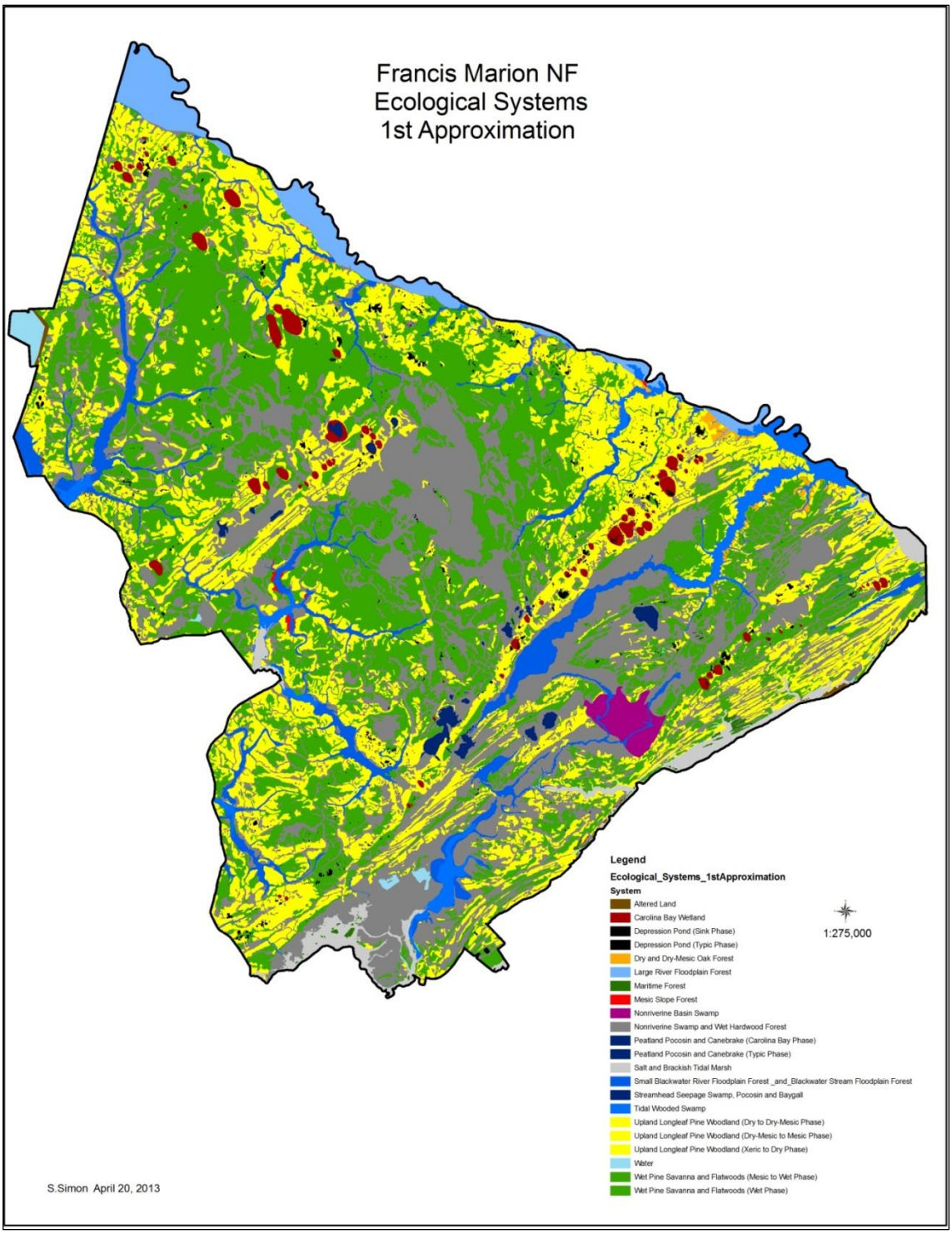


Figure 2-2. Terrestrial ecosystems within the Francis Marion proclamation boundary

Table 2-1. Terrestrial ecosystem acreage, both within proclamation and administrative boundaries

Ecological System	Acreage within Proclamation Boundary	# map units	Acreage within Administrative Boundary
Upland Longleaf Pine Woodland (total acres)	106,130		53,857
Upland Longleaf Pine Woodland (xeric_dry phase)	15,540		8,529
Upland Longleaf Pine Woodland (dry_dry-mesic phase)	20,630		7,944
Upland Longleaf Pine Woodland (dry-mesic_mesic phase)	69,960		37,384
Maritime Forest	476	82	416
Dry and Dry-Mesic Oak Forest	1,110	55	885
Mesic Slope Forest	225	21	214
Blackwater Stream Floodplain & Blackwater River Floodplain	19,100		11,374
Large River Floodplain	8,680		3,710
Tidal Wooded Swamp	7,865		5,217
Nonriverine Swamp and Wet Hardwood Forest	113,770		80,602
Peatland Pocosin and Canebrake	2,030	15	2,027
“Pocosin in Carolina Bay”	270	3	252
Streamhead Seepage Swamp, Pocosin and Baygall	75	19	76
Nonriverine Basin Swamp	2,745		2,483
Carolina Bay Wetland	4,510	83	3,264
Depression Pondshore	2,095	435	1,331
“Depression Pondshore Small Sinks”	330	923	204
Wet Pine Savanna and Flatwoods (total acres)	138,320		90,735
Wet Pine Savanna and Flatwoods (mesic_wet phase)	92,750		55,516
Wet Pine Savanna and Flatwoods (wet phase)	45,570		35,219
Fresh and Oligohaline Tidal Marsh	0		
Salt and Brackish Tidal Marsh	6,660	41	2,568
“Altered Land”	550		77
“Water”	1,650		55
Total	**416,600**		**259,345**

2.1.1.4 Information Provided by Interested Parties

To develop the first draft of ecological systems, we worked with internal Forest and regional personnel, with Natureserve representatives (Milo Pyne and Carl Nordman), and with ecological contractors Steve Simon and Larry Hayden, and met in the field on November 7–9, 2012, and again on April 10–11, 2013. The 1st approximation of the ecological systems map was released to both Forest Service and to Natureserve representatives for comment on April 24, 2013, to interested internal personnel for comment; and to the South Carolina Nature Conservancy (SCTNC). The Forest met with the Southern Research Station and the Santee Experimental Station to discuss influence and approaches for addressing hydrology within the ecological classification on February 5, 2013. Preliminary findings related to longleaf pine ecosystems were presented to the Sewee Longleaf Conservation Cooperate (June 4, 2013). The Forest Service with SCTNC and the Coastal Conservation League presented preliminary findings related to longleaf pine ecosystems at an Ecological Sustainability Forum on August 6, 2013. Interaction with species and ecosystem experts and Agency personnel is ongoing throughout the planning process.

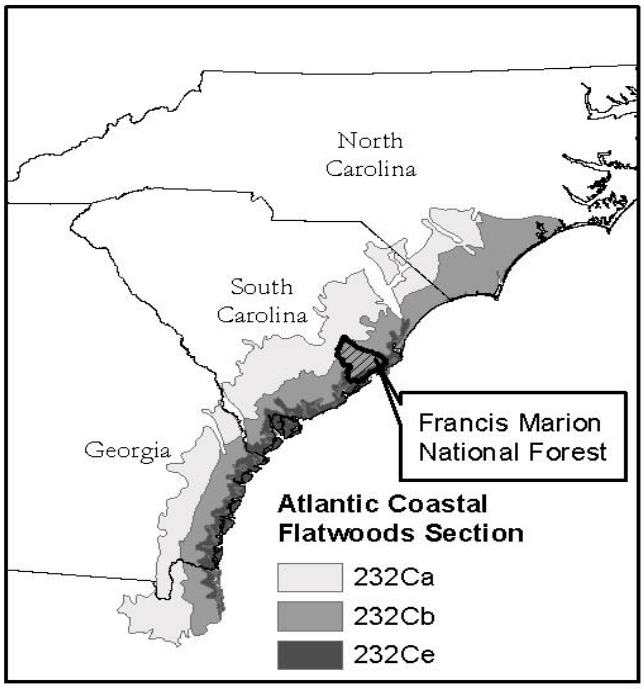


Figure 2-3. Atlantic Coastal Flatwoods Ecological Section

2.1.1.5 Broader Landscape

The Francis Marion National Forest occurs within the outer Atlantic Coastal Plain, also known as the Atlantic Coastal Flatwoods Section (Figure 2-3) and includes portions of upper terraces (232Ca), lower terraces (232Cb) and coastal marsh and island (232Ce) subsections. The Atlantic Coastal Plain Flatwoods Section is characterized by weakly dissected, flat alluvial plains of well drained deep sands with local areas of highly organic soils (Cleland et al. 2007).

The Francis Marion National Forest is considered a significant landscape for longleaf pine conservation by America's Longleaf, a collaborative effort of multiple public and private sector partners that actively supports rangewide efforts to restore and conserve Longleaf Pine Ecosystems (ALRI 2009). Longleaf pine forests, woodlands, and savannas were once among the most extensive ecosystems in North America. Prior to European settlement, these forests occupied more than 90 million acres in the southeastern United States (Frost 1993; Brockway et al. 2002; ALRI 2009). Today, there are an estimated 3,404,143 acres, with the majority occurring on private lands. Table 2-2, taken from the Range-Wide Conservation Plan for Longleaf Pine (2009), shows that in 2009, the majority (55 percent) of South Carolina's longleaf pine forests occurred on private lands.

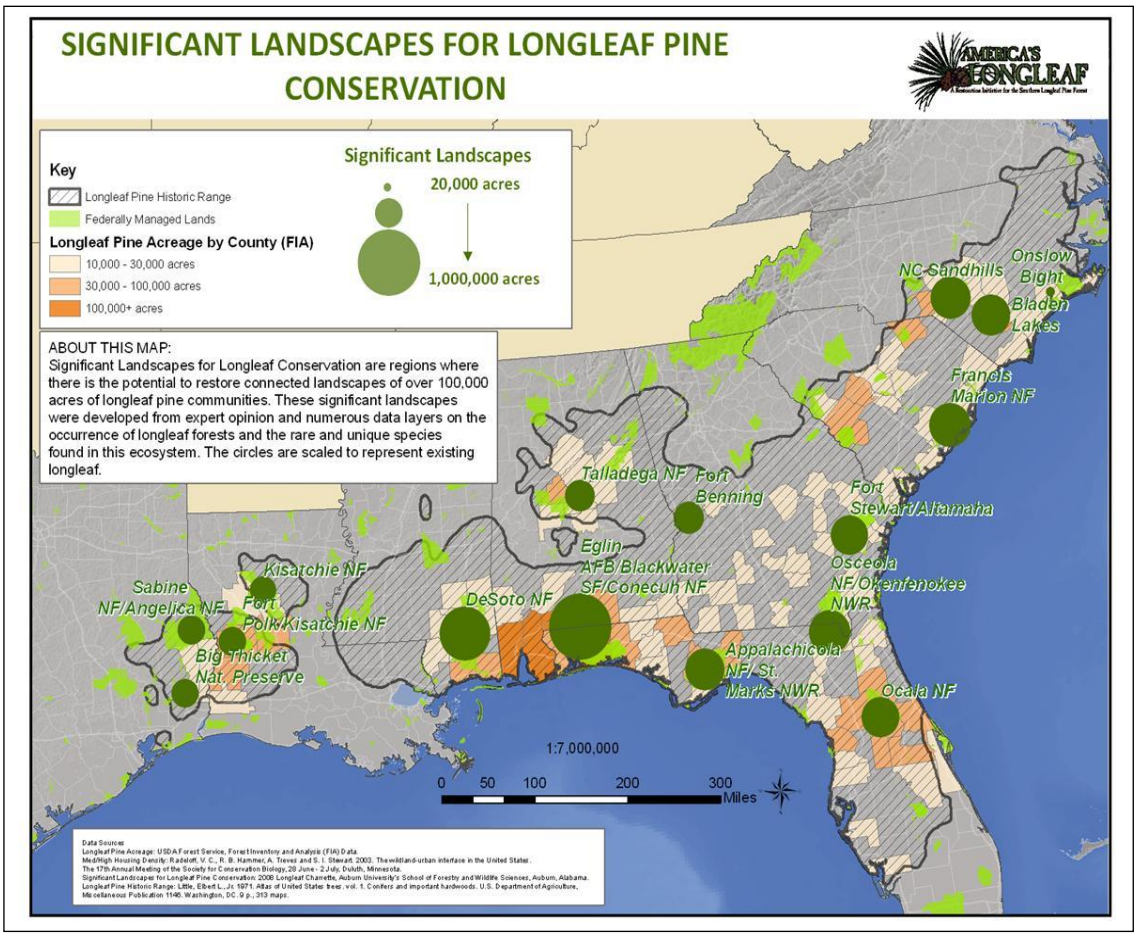


Figure 2-4. America's longleaf significant landscapes for longleaf pine conservation

Table 2-2. Estimates of existing acres of longleaf forest type by ownership category

State	Total	NFS	USFWS	DOD	Other Federal	State	County & Munic-ipal	Private
Georgia	460,109	609	10,500	40,000	6,000	6,000	0	397,000
North Carolina	220,338	15,088	300	34,000	0	33,000	2,000	136,000
South Carolina	401,980	36,980	42,000	46,000	3,000	51,000	0	223,000
Total	**1,082,427**	**52,677**	**52,800**	**120,000**	**9,000**	**90,000**	**2,000**	**756,000**

2.1.1.6 Past and Likely Future Trends

Upland Longleaf Pine Woodlands and Wet Pine Savannas and Flatwoods

Key Ecosystem Characteristics

Relative Abundance, Condition, and Landscape Pattern. The Francis Marion National Forest contains two longleaf-dominated native matrix ecological systems, Upland Longleaf Pine Woodlands, and Wet Pine Savannas and Flatwoods. Upland Longleaf Ecosystems occur on sandy ridges, and are typically dominated by longleaf pine; Whereas Wet Pine Savanna And Flatwoods Ecosystems occur on wet, seasonally saturated, mineral soils, and can be dominated by longleaf pine, pond pine, or loblolly pine on wetter sites. Variants within each type can be

recognized that differ in structure, in associated understory and woody species, and in soils and subtle changes in landform.

In their travels, Bartram (1791) described over half of the upland landscape from Virginia to Texas as a "…vast forest of the most stately pine trees that can be imagined…" and Sargent (1884) described longleaf pine as the "prevailing growth" on the uplands (Frost 1993). The demise of the Longleaf Pine Ecosystem throughout the Southeast resulted from land clearing; the introduction of hogs and feral livestock into the woods that feasted on longleaf pine seedlings; the turpentine industry; regeneration of loblolly pine in place of longleaf pine; and fire suppression. By 1900 it was evident that longleaf pine replaced itself only sporadically in a tiny percentage of its former landscape (Frost 1993). The near elimination of once-dominant Longleaf Pine Ecosystems was perhaps the greatest ecosystem alteration resulting from intensive forest management and land use conversion in the South (Wear and Greis 2012).

The 1996 revised Forest plan recognized the importance of the Longleaf Pine Ecosystems, but estimated the range of longleaf pine historically on the Francis Marion National Forest at between 37,000 and 75,000 acres, and the goal for Longleaf Pine Ecosystem expansion at 21 percent of the Forest (1996 revised plan, page1-6; and ROD, page18). Restoration, expansion, and maintenance of Longleaf Pine Ecosystems and related fire-dependent communities were emphasized within management area 26 (sandy ridge and sideslopes). Though not formally recognized as a matrix ecosystem in the 1996 revised Forest plan, the majority of the Wet Pine and Flatwoods Ecosystem was placed in management area 28, "Flatwoods and Loamy Ridges", a management area with no single goal emphasis, and where "loblolly pine is the dominant species on the upland sites" (Table 2-3). The revised plan did include objectives to identify and maintain plant communities including pine and pond cypress savannas; several high quality examples are captured on a GIS coverage or as designated botanical areas for the Forest (Gaddy et al. 2012; Glitzenstein and Streng 2010; Everett 2010; Porcher 1995). Monitoring of the few designated botanical areas in pine savannas (Awendaw Savanna and Big Opening of Hell Hole, for instance) suggests that there have been declines in their condition due to lack of frequent prescribed fire, and the resulting succession by woody species.

In 2010, as part of a longleaf assessment process, the USDA Forest Service with the South Carolina Nature Conservancy identified two matrix longleaf ecosystems on the forest: an Upland Longleaf Woodland Ecosystem and a Wet Pine Savanna and Flatwoods Ecosystem. It was predicted at that time that the extent of existing and restorable longleaf pine was closer to 130,000 acres. As a result of ecological modeling in 2013, Simon and Hayden have identified 53,857 acres in the Upland Longleaf Pine Woodland Ecosystem, but an additional 90,735 acres in Wet Pine Savanna and Flatwoods (144,592 acres total). The Wet Pine Savanna and Flatwoods Ecosystem is now recognized as the most dominant ecological system historically on the Forest, representing 55 percent of the total Forest acreage.

Table 2-3 shows the existing and potential Upland Longleaf and Wet Pine Savanna Ecological systems by 1996 Forest Plan management area.

Table 2-3. Upland longleaf and wet pine savanna ecological systems by 1996 management area based on 2013 ecological modeling

	Upland Longleaf Woodlands		Wet Pine Savanna and Flatwoods		
Management Area	**Acres**	**% of Total**	**Acres**	**% of Total**	**Grand Total**
1	236	0.44	402	0.45	638
2	391	0.73	478	0.53	869
4	1,303	2.43	2,281	2.53	3,584
8	868	1.62	397	0.44	1,265
26	42,852	79.94	35,206	38.99	78,058
27	1,893	3.53	8,548	9.47	10,441
28	5,512	10.28	39,444	43.68	44,956
29	552	1.03	3,542	3.92	4,094
Grand Total	**53,607**	**100.00**	**90,297**	**100.00**	**143,904**

In 2010, in conjunction with the South Carolina Nature Conservancy, the Forest collected information on the condition of Longleaf Pine Ecosystems on the Forest, which included consideration of overstory, midstory, and understory conditions. Condition classes included the following (from America's Longleaf, Rangewide Conservation Plan, [2009]):

> *Maintain* = Forest canopy and understory conditions that currently will provide ecosystem functions, processes, and assemblages of representative species of plants and animals. The maintain condition class was grouped to include maintain, improve ground only, improve mid-story only, improve canopy only, and restore canopy only management classes.
>
> *Improve* = Longleaf pine may be present, but lack significant components of understory communities and fire regimes to support representative communities. Tree cover may be dense.
>
> *Restore* = Stands do not currently support a longleaf pine canopy nor understory, but could be reintroduced based on ecological modeling or presence of representative soils.

Using the results of the 2010 longleaf assessment, which included field assessments, and then intersecting this information with the modeled data for Longleaf Ecosystems, of a total 129,492 acres evaluated, 19,663 acres (13.6 percent) of our Longleaf Ecosystems were in good condition (i.e., "maintain" class) in 2010, including 8,213 acres in upland longleaf (15.2 percent) and 8,639 acres (9.5 percent) in Wet Pine Savanna and Flatwood Ecosystems (Table 2-4). This suggests that we are currently maintaining 13.6 percent of our Longleaf Pine Ecosystems in conditions that will provide ecosystem functions, processes, and assemblages or representative species of plants and animals, compared to the goal for Longleaf Pine Ecosystem expansion for 21 percent of the Forest (1996 revised plan, page1-6; and ROD, page18).

Table 2-4. Longleaf condition classes from 2010 longleaf assessment, by Longleaf Ecosystem type (in acres)

Condition Class	Upland Longleaf	Wet Pine Savanna	Other[1]	Total
Improve	8,551	10,336	3,568	22,455
Maintain	8,213	8,639	2,811	19,663
Restore	12,458	28159	6,469	47,086
No condition class	78	198	31	306
Total	**29,299**	**47,331**	**12,879**	**89,510**

[1] Represents other ecosystems included within stands inventoried as part of the longleaf assessment.

Since 1996, several initiatives have encouraged expansion of longleaf pine and associated ecosystems on the Forest. The 15-year goal for America's Longleaf Conservation Plan (2006) is to more than double the longleaf acreage in significant landscapes in maintain, improve, and restore categories, and in ways to support a majority of ecological and species (page 5-6, ALRI, 2009). The Sewee Longleaf Conservation Cooperative encourages government agencies, nongovernmental organizations, private landowners, practitioners and other stakeholders to re-establish, maintain, and enhance the Longleaf Pine Ecosystem in the Sewee landscape (centered in and around the Francis Marion National Forest) through resource sharing, collaboration, and applied learning. These partnership efforts—which include the U.S. Fish and Wildlife Service, the National Wild Turkey Federation, the Southeastern Association of Fish and Wildlife Agencies, the South Carolina Forestry Commission, and the Department of Defense, among others—lend support to increasing longleaf pine ecosystems and restoration efforts on the Forest in the future.

Longleaf pine may be most suitable for climate change mitigation, due to superior tolerance to both drought and low soil nutrition; greater resistance to insects, diseases, and wind damage; long rotations and long-term carbon storage; and less energy inputs relative to more intensively loblolly pine (Samuelson et al. 2012). Predictions on the incidence of savannas are mixed; one prediction is that reductions in the frequency of fires and hurricanes associated with global warming may push southeastern pine savannas towards a forested state with an increased overstory density and reduced understory component. Another prediction is that closed-canopy forests may be converted to savanna, woodland, or grassland under temperature-induced drought stress and a significant increase in the intensity of fire disturbance.

Landscape pattern which connects fire-maintained longleaf ecosystems with associated depression ponds, pocossins, seepage slopes, and Carolina bays is important for maintaining native biodiversity; and for promoting gene flow and for species migrations, particularly in the face of climate change, for re-colonization of species following interruption of fire regimes, and for maintaining the life cycles of aquatic and terrestrial at-risk species. The 1996 revised Forest plan provided connectivity for longleaf ecosystems within management area 26, but this management area does not well reflect all the diversity of longleaf ecosystems on the Forest and our ability to maintain them. One should consider the distribution of existing and restorable longleaf pine ecosystems in the improve and maintain condition class, distributions of fire-dependent and associated at-risk plants and wildlife, forest burn blocks, and possible old-growth longleaf pine, to identify our best opportunities for connecting longleaf pine fragments and providing for large and medium-sized blocks for maintaining and restoring ecosystem processes and function. The revised recovery plan for the red-cockaded woodpecker includes guidance that foraging habitat is not separated by more than 200 foot of non-foraging habitat (Recovery

Standards for the Red-cockaded Woodpecker, USDI Fish and Wildlife Service [2003]; pages 188–189).

Possible Old Growth. Old growth forests suggest large trees, accumulations of large-sized dead standing and fallen trees, canopy gaps and multiple canopy layers, and wide variation in tree sizes and spacing (USDA Forest Service 1997). Characteristics specific to longleaf forests include open park-like stands of pine with species-rich herbaceous layer dominated by grasses. Canopies are believed to naturally be two-aged or uneven-aged, consisting of a fine mosaic of small even-aged groves driven by gap phase regeneration. Given the land use history of Southern forests, very little true old growth exists today, yet restoration of old growth for future generations is desirable for biological, social, or spiritual reasons. Minimally to moderately disturbed second growth longleaf pine forests could make an important contribution to old-growth resources in the future (Walker 1999).

The minimum age for longleaf pine old growth ranges from 150 to 200 years (USDA Forest Service 1997), though Walker (1999) notes that old-growth characteristics can be observed in stands as young as 100 years. In a working draft of maintenance condition class definitions for longleaf-association communities (2013), the longleaf partnership council identifies the presence of the following in addition to other maintenance condition class criteria, as evidence of old growth characteristics in longleaf pine community types/stands: (1) Large trees present (≥20 square feet/acre of trees ≥14 inch dbh class), and (2) flat top trees (old individuals) present in the canopy.

Old growth was evaluated in the 1996 FEIS (pages III-33–36) to include forested stands greater than 100 years and stands withdrawn from timber production. There was little old growth direction in the Forest plan specific to the distribution of old growth, relationship to community or ecosystem type, and consideration of characteristics of old growth other than age and suitability. It was assumed that even-aged stands managed for red-cockaded woodpecker would provide suitable old-growth conditions in the future.

We will follow the process for providing for old growth included in the "Guidance for Conserving and Restoring Old-Growth Communities on National Forests in the Southern Region", which represents a coordinated effort within the Southern Region for consistently addressing the old-growth resources during Forest and project-level planning (USDA Forest Service 1997). The guidance recommends that a network of old-growth areas of various sizes be developed which consider a representation of all potential old-growth forest community types, that linkages among old-growth patches be considered, and that old-growth amounts allocated within the Forest plan consider public input and issues. Consistent with this guidance, a preliminary inventory of possible old growth is being conducted using available forest vegetation data. To assess the areas on the Forest meeting the criteria for possible old growth based on the guidance, we looked at stands on the Forest meeting a minimum age criteria of ≥110 years (age year ≤1903), which is the minimum half-life for our predominant longleaf communities based on the old growth guidance, as well as those meeting age criteria of ≥100 years.

The 1996 FEIS displayed 3,668 acres of old-growth longleaf forest types, including mixtures of other species. Using stand age and forest type criteria from FS VEG in 2013, 3,583 acres of longleaf pine stands are ≥100 years and 795 acres are ≥110 years in FS VEG (Table 2-5). Stands modeled as longleaf pine ecosystems and meeting the age criteria of 110 years, recommended in the Southern Old Growth Guidance, occur on 2 and 1.1 percent, respectively, of Upland Longleaf and Wet Savanna and Flatwoods Ecological System sites (Table 2-6). This information

does not address structure, function, or composition above and beyond age of the oldest age class of trees.

Table 2-5. Trends in possible old growth in longleaf forest types

	1996 FEIS		2013	
	Suitable Lands >100 years	Unsuitable Lands	≥110 years	≥100 years
Longleaf Pine and mixtures	527	3,141	795	3,583

Table 2-6. Possible old growth (≥110 years) by Longleaf Pine Ecological System

Ecological System	Total Acres	Percent of Total Old Growth	Percent of Total for Ecological System	Associated Forest Types
Upland Longleaf Pine Woodland	1,106	11.0%	2.0%	Longleaf pine; loblolly pine; loblolly pine-hardwood; sweetgum-oak; sweetbay-swamp tupelo-red maple; bald cypress-water tupelo; oak hammock
Wet Pine Savanna and Flatwoods	975	9.7%	1.1%	Bald cypress-water tupelo; bottomland hardwood-yellow pine; loblolly pine-longleaf pine; longleaf pine; loblolly pine

Fire Regime. Lack of frequent prescribed fire is a primary threat to Longleaf Pine Ecosystem integrity particularly herbaceous understory communities. The Forest Service recognized the importance of frequent prescribed fire in maintaining Longleaf Ecosystems in 1996, and included a standard that management area 26 be prescribed burned on a 2- to 3-year rotation. However, from 2007 through 2011, less than half of management area 26 had been prescribed burned on a 3-year rotation (25 percent in 2007, 44 percent in 2008, 48 percent in 2009, 29 percent in 2010, and 25 percent in 2011). In response to smoke management concerns in the wildland-urban interface, in 2007 the district developed a "core burn area" within which frequent fire was more commonly practiced. More recent research shows an increase in plant species richness across a 1- to 3-year-fire-regime interval depending on openness of the canopy, and greatest herbaceous dominance at 1- to 2-year-fire-return intervals, particularly in Wet Pine Savannas and Flatwoods where the potential for competition by woody shrubs is highest (Glitzenstein and Streng 2003; Glitzenstein et al. 2012).

Table 2-7 shows prescribed burning frequencies for all ecosystems, including potential and existing Upland Longleaf and Wet Pine Savannas on the Forest (this table will be referred to in the analysis for all ecosystem sections). Between 2005 and 2012, 19,597 acres (36 percent) of potential and existing upland longleaf woodlands and 27,138 acres (15 percent) of the Wet Pine Savanna and Flatwoods Ecosystem were burned three or more times (2.6 year burning rotation). The total acres prescribed burned on the Forest have remained fairly constant, but have not met the long-term objectives (see section 3.4 "Wildland Fire and Fuels") for total burning and growing season burning within longleaf pine forest types.

Table 2-7. Prescribed fire in ecological systems on the Francis Marion National Forest (2005–2012)

	1 Burn	2 Burns	2 Burns; 1 or More Growing Seasons	3 Burns	3 Burns; 1 or More Growing Seasons	More Than 3 Burns	Total Acres Ecological System Prescribed Burn ≥3 Times	% Ecological System Prescribed Burn ≥3 Times
Carolina Bay Wetland	530	6	52	231	96	339	666	20%
Depression Pond	348	49	98	120	122	270	512	38%
Dry and Dry-Mesic Oak Forest	125	3	31	116		549	665	75%
Large River Floodplain Forest	1,234			22		376	398	11%
Mesic Slope Forest	9	5	8	8			8	0%
Nonriverine Basin Swamp	29					19	19	1%
Nonriverine Swamp and Wet Hardwood Forest	9,199	4,744	5,657	2,164	13,986	8,754	24,904	31%
Peatland Pocosin and Canebrake, inclunding Streamhead Pocossin	477	22	67		1,251	116	1,367	65%
Small Blackwater River Floodplain Forest _and_Blackwater Stream Floodplain Forest	1,189	572	201	367	539	579	1,485	13%
Tidal Wooded Swamp	28	14		648	54	2,102	2,804	54%
Upland Longleaf Pine Woodland (TOTAL)	5,973	2,612	77.94	5,754	4,392	9,451	19,597	36%
Upland Longleaf Pine Woodland (Xeric_Dry_Phase)	1,699	421	326	1,812	352	1,933	4,097	48%
Upland Longleaf Pine Woodland (Dry_Dry-Mesic phase)	640	120	78	100	273	2,326	3,699	29%
Upland Longleaf Pine Woodland (Dry-Mesic_Mesic _Phase)	3,633	2,071	3,579	2,842	3,768	5,192	11,802	14%
Wet Pine Savanna and Flatwoods (Total)	14,847	4,144	5,792	3,368	9,999	13,771	27,138	15%
Wet Pine Savanna and Flatwoods (Mesic_Wet Phase)	9,171	2,590	3,874	2,200	5,455	7,633	15,288	14%
Wet Pine Savanna and Flatwoods (Wet Phase)	5,676	1,554	1,918	1,167	4,544	6,139	11,851	17%
Grand Total	**33,985**	**12,170**	**15,890**	**12,797**	**30,439**	**36,326**	**79,563**	**31% of Total Forest Area**

Structural Diversity and Natural Range of Variation (NRV). Natural Upland Longleaf Pine Woodland Ecosystem canopies are open and park-like, but many-aged, consisting of a network of forest patches at various ages. Gap phase regeneration produces a forest structure of even-aged patches within an uneven-aged mosaic (Longleaf Partnership Working Draft 2013; Natureserve 2012; Brockway et al. 2002; Landfire Biophysical Setting Models for Atlantic Coastal Plain Upland Longleaf Pine Woodland and for Southern Atlantic Coastal Plain Wet Pine Savanna and Flatwoods). Within a natural disturbance regime of frequent fire, woodlands (26 to 60 percent forest cover) and savannas (5 to 25 percent forest cover) structural classes were predominant across much of the landscape. In a working draft of maintenance condition class definitions by the Longleaf Partnership Council (2013), minimum standards for achieving the "maintenance condition" for longleaf-associated communities is a longleaf pine canopy which is two-tiered age, or uneven-aged in structure, with longleaf pine basal area of 40 to 70 square feet, with a lower range down to 10 square feet for wet savanna communities. Other metrics identified include a basal area of canopy hardwoods or off-site pines <10 square feet/acre, shrubs averaging ≤30 percent cover, and mid-story ≤20 percent cover, continuous herbaceous cover ≤65 percent, and advance longleaf regeneration around 10 percent.

In the 1996 revised Forest plan, timber management was typically even-aged, particularly within 0.5 mile of red-cockaded woodpecker clusters and on soils classified as very poorly, or poorly drained due to operational constraints (FEIS, page II-40). The recovery plan for the red-cockaded woodpecker was revised in 2003 and recommends that foraging habitat (within 0.5 miles of the center of active clusters) contain a basal area of all pines ≥10 inches dbh of at least 40 square feet/acre; native herbaceous groundcovers which total at 40 percent; no hardwood midstory, and if present, that it be sparse and less than 7 feet in height. The plan also recognizes that extremely dry and extremely wet longleaf habitats may be unable to support these characteristics (USDI Fish and Wildlife Service 2003). Table 2-8, which will be referred to in the analysis for all sections, shows the acres in early succession, savanna, woodland, and forested ecosystems, for each of our modeled ecosystems, based on LIDAR analysis of canopy cover, where early succession equals 0–5 percent canopy cover, savanna equals 5–26 percent canopy cover, woodland equals 26–60 percent canopy cover, and forest equals 60–100 percent canopy cover. This table suggests that on the Francis Marion National Forest, 27.5 percent of our forests have open canopies, including 34 percent of our longleaf ecosystems. On the Francis Marion National Forest, 22,727 acres (9 percent of the Forest) are in early successional or savanna condition (less than 26 percent canopy cover). The 1996 revised plan contained an objective to maintain 5,000 to 10,000 acres in early successional habitat, suggesting that objective has been met and exceeded.

Ecological departure rankings in regard to vegetation structure alone were calculated using a process described by Low et al. (2010) and relevant BioPhysical Settings models from LANDFIRE (LANDFIRE a and g, 2006). Both Southern Atlantic Coastal Plain Wet Pine Savanna and Flatwoods (biophysical settting Model 5814500) and Atlantic Coastal Plain Upland Longleaf Pine Woodland (biophysical setting 581347), were used in this analysis. We compared vegetation classes from the biophysical settings models, including age class and structural breakouts to define each class, to those found on the Forest using Forest FS VEG even-aged age class data, and LIDAR shade data to quantify canopy opening. Then, ecological departure rankings were calculated based on Low et al. (2010), by summing the lowest range of variables and subtracting from 100, where low departures = 033 percent, medium = 34–66 percent, and high = 67–100 percent. Table 2-9 suggests that our landscapes on the Francis Marion deviate moderately in regard to structure, and that we have low levels of late open conditions compared to reference conditions as described in LANDFIRE biophysical settings models.

Table 2-8. Acreage in grassland, savanna, woodland, and forest structural classes by ecological system based on LIDAR-derived canopy cover using GIS

Ecological System	Grassland (0–5%)	Savanna (5–25%)	Woodland (26–60%)	Forest (>60%)	Total
Altered Land	2	5	19	50	76
Carolina Bay Wetland	154	381	663	2,022	3,220
Depression Pond (Sink Phase)	3	13	45	141	202
Depression Pond (Typic Phase)	20	71	241	988	1,321
Dry and Dry-Mesic Oak Forest	5	16	130	733	885
Large River Floodplain Forest	20	25	147	3,428	3,620
Maritime Forest	45	39	61	269	415
Mesic Slope Forest	0.06	0.4	5	208	214
Nonriverine Basin Swamp		0.3	14	2,469	2,483
Nonriverine Swamp and Wet Hardwood Forest	1,048	4,259	9,760	65,586	80,653
Peatland Pocosin and Canebrake (Carolina Bay Phase)	9	34	56	151	250
Peatland Pocosin and Canebrake (Typic Phase)	980	770	201	77	2,027
Salt and Brackish Tidal Marsh	2,135	164	86	90	2,476
Small Blackwater River Floodplain Forest and Blackwater Stream Floodplain Forest	26	124	445	10,765	11,360
Streamhead Seepage Swamp, Pocosin and Baygall	22	25	17	12	75
Tidal Wooded Swamp	48	55	148	4,951	5,203
Upland Longleaf Pine Woodland (Dry to Dry-Mesic Phase)	82	343	1,819	5,662	7,906
Upland Longleaf Pine Woodland (Dry-Mesic to Mesic Phase)	538	2,645	10,897	23,210	37,290
Upland Longleaf Pine Woodland (Xeric to Dry Phase)	96	385	3,334	4,731	8,546
Water	8	6	13	27	54
Wet Pine Savanna and Flatwoods (Mesic to Wet Phase)	914	3,987	13,711	36,562	55,174
Wet Pine Savanna and Flatwoods (Wet Phase)	702	2,532	6,574	25,227	35,035
Grand Total	**6,857 (3%)**	**15,880 (6%)**	**48,386 (19%)**	**187,360 (72%)**	**258,482**

Table 2-9. Ecological departure rankings for Upland Longleaf and Wet Pine Savanna ecosystems[1]

Ecological System	Early-Class A		Mid-Closed		Mid-Open		Late-Closed		Late-Open		Ecological Departure
	Current	Predicted	Current	Predicted	Current	Predicted	Current	Predicted	Current	Predicted	
Upland Longleaf	8	13	47	5	22	40	15	2	7	40	56
Wet Pine Savanna and Flatwoods	9	15	45	5	13	35	23	10	9	35	53

[1] Low = 0–33%, medium = 34–66%, and high = 67–100% levels of departure.

Herbaceous Understories. The high diversity of herbaceous understory plants per unit area make Longleaf Pine Ecosystems among the most species-rich outside the tropics (Peet and Allard 1993). Understory grasses facilitate the ignition and spread of prescribed fire and form the base of the food chain for numerous wildlife species, particularly birds and pollinator species. The 1996 revised plan did not directly address conditions for herbaceous groundcover. Ecological integrity indices for longleaf pine ecosystems, developed in a working draft for the Southern Region by the Forest Service in conjunction with Natureserve in 2011 (by Forest contractor Dr. Jean Everett) for wet savannas on the Francis Marion National Forest in 2010, and through a working draft of the Longleaf Partnership Council in 2013, include consideration of abundance and diversity of herbaceous groundcover. Everett included rankings for assessing native grass and forb diversity, native grass and forb abundance, and rare species diversity and abundance in an ecological integrity ranking for wet pine savannas. In a working draft of maintenance condition class definitions by the Longleaf Partnership Council (2013), minimum standards for achieving the "maintenance condition" for longleaf-associated communities is a continuous herbaceous cover ≥65 percent.

Stressors and Threats

Nonnative Invasive Species. Nonnative invasive species, though not addressed in the 1996 revised Forest plan, are a primary threat to Longleaf Ecosystems, particularly those undergoing restoration (Natureserve and USDA-Forest Service 2011; Natureserve 2012; Degarady 2013). Feral hogs and cogongrass are most commonly cited threats, but on the Francis Marion National Forest, Japanese climbing fern is also a major concern. Japanese climbing fern, which has the potential to disrupt fire regimes, was identified as an early detection and rapid response species by the South Carolina Exotic Pest Plant Council (se-eppc.org), and is now the most common invasive plant species on the Forest (68 percent or 1,888 of 2,769 records in Longleaf Ecosystems).

The establishment of saturation densities of feral hogs is one of the primary agents responsible for the demise of the Longleaf Ecosystem (Frost 1993), and they continue to impact our longleaf forests and associated wetlands today. Cogongrass, a Federal and state noxious weed, occurs at three locations on the Forest, and is near controllable levels, but statewide surveys for cogongrass continue to be a priority for the South Carolina Cogongrass Task Force, and for the Forest Service.

Table 2-10, which will be used in the analysis of all sections, shows terrestrial invasive plant species documented within all ecological systems. See the invasive species section for a complete listing of all nonnative invasive plants documented to date on the Forest. Species with five or more records within Longleaf Pine Ecosystems include Japanese climbing fern, Japanese honeysuckle, Chinese privet, Japanese stiltgrass, Sericea lespedeza, tall fescue, mimosa, small carpet grass, Chinaberry, Chinese wisteria, autumn olive, and Chinese tallow.

The South Carolina Comprehensive Wildlife Strategy (2011) includes as a high priority conservation action preventing the spread of existing invasive and nonnative species, and eliminating them, where possible. Invasive plant species are expected to increase with changes in climate (South Carolina Department of Natural Resources [SCDNR] 2013), and will increasingly threaten ecological integrity of Longleaf Pine Ecosystems in the future.

Table 2-10. Invasive plant species counts by ecological system

Ecological System	Count
Altered Land	5
Depression Pond (Sink Phase)	28
Depression Pond (Typic Phase)	41
Dry and Dry-Mesic Oak Forest	102
Large River Floodplain Forest	897
Maritime Forest	9
Mesic Slope Forest	34
Nonriverine Swamp and Wet Hardwood Forest	413
Salt and Brackish Tidal Marsh	2
Small Blackwater River Floodplain Forest and Blackwater Stream Floodplain Forest	168
Tidal Wooded Swamp	369
Upland Longleaf Pine Woodland (Dry to Dry-Mesic Phase)	472
Upland Longleaf Pine Woodland (Dry-Mesic to Mesic Phase)	1,278
Upland Longleaf Pine Woodland (Xeric to Dry Phase)	36
Wet Pine Savanna and Flatwoods (Mesic to Wet Phase)	678
Wet Pine Savanna and Flatwoods (Wet Phase)	305
Grand Total	**4,837**

Dense Canopies of Loblolly Pine. Although the acreage in loblolly pine forest types on the Forest has declined from 114,917 acres in 1985 (FEIS, 1985 and "Forest Products" section), this decline represents a shift to changes from pure loblolly pine to mixtures with hardwoods. Loblolly pine is currently the most abundant tree species on the Francis Marion National Forest occupying over 104,376 acres (includes mixtures with hardwoods), and much of this occurs as forests >60 percent canopy cover. The majority of our loblolly pine forests occur on longleaf pine ecosystem sites, including 25,673 acres on upland longleaf sites, 50,760 acres on wet pine savanna sites (Table 2-11).

Early in the history of the Forest, the emphasis was on sustained yield and on cooperation with timber companies, who controlled the majority of the forest land in the coastal pine belt (Hector 1979). Several large timber companies began building mills and buying up land and stumpage in the area in and around the Francis Marion National Forest around 1899. Within a decade timber companies owned most of the forest land in Berkeley, Georgetown, and upper Charleston counties, and Atlantic Coast Lumber Corporation was considered one of the largest producers of timber on the Eastern seaboard. In consultation with the new Federal Bureau of Forestry, longleaf and hardwoods were eliminated and replaced with loblolly pine whenever possible, mainly because loblolly pine grew and reproduced rapidly, and fire was to be kept out of the woods completely to allow loblolly to reproduce to its full potential (Hector 1997). Given their influence on ecosystem composition, structure, function, and connectivity, their abundance on the Forest is evaluated based on their threat to the ecological integrity of longleaf pine ecosystems. Table 2-11 shows existing vegetation on the Forest using forest type groups from FSVEG, and may also be referred to in other sections.

Table 2-11. Acres by forest type group from FSVEG, 2013, and by ecological system

Forest Type Group	Bottomland Hardwood (including Oak) or Mixed Hardwood/ Yellow Pine or Sweetgum	Loblolly Pine and Mixtures with Hardwood (No Oak Listed)	Longleaf Pine and Mixtures with Loblolly or Slash Pine	No Forest Type Group	Pond Cypress and/or Bald Cypress	Pond Pine, Pond Pine/Hardwood, Brush Species, Undrained Flatwoods, Sweetbay, Swamp Tupelo, Red Maple	Upland Hardwood (including Oak) or Mixed Hardwood/Yellow Pine or Shortleaf Pine	Grand Total
Forest Type	46, 61, 62, 63, 64	13, 31	21, 22, 27, 29	(blank)	23, 24, 67	18, 36, 40, 68, 98, 99	10, 11, 44, 47, 48, 49, 53, 57, 58, 77	
Altered Land	20	24	24	6	2			76
Carolina Bay Wetland	147	1,189	251	2	602	1,027	2	3,220
Depression Pond (Sink Phase)	9	98	75	1	9	8	2	202
Depression Pond (Typic Phase)	38	471	304	11	350	130	14	1,318
Dry and Dry-Mesic Oak Forest	40	476	110	18	76	9	155	885
Large River Floodplain Forest	722	161	1	4	2,585	165	4	3,642
Maritime Forest	93	137	12	130		13	32	416
Mesic Slope Forest	120	49			16		28	214
Nonriverine Basin Swamp	1,248	96			1,130	3	5	2,483
Nonriverine Swamp and Wet Hardwood Forest	11,601	23,310	7,070	115	17,166	20,180	844	80,287
Peatland Pocosin and Canebrake (Carolina Bay Phase)	123	11				116		250
Peatland Pocosin and Canebrake (Typic Phase)		1	5		16	2,006		2,027
Salt and Brackish Tidal Marsh	92	245	14	1,058		1,088	55	2,551
Small Blackwater River Floodplain Forest and	3,938	1,257	101	40	2,284	3,484	238	11,341

Forest Type Group	Bottomland Hardwood (including Oak) or Mixed Hardwood/ Yellow Pine or Sweetgum	Loblolly Pine and Mixtures with Hardwood (No Oak Listed)	Longleaf Pine and Mixtures with Loblolly or Slash Pine	No Forest Type Group	Pond Cypress and/or Bald Cypress	Pond Pine, Pond Pine/Hardwood, Brush Species, Undrained Flatwoods, Sweetbay, Swamp Tupelo, Red Maple	Upland Hardwood (including Oak) or Mixed Hardwood/Yellow Pine or Shortleaf Pine	Grand Total
Blackwater Stream Floodplain Forest								
Streamhead Seepage Swamp, Pocosin and Baygall	1	2	18		3	52		75
Tidal Wooded Swamp	1,340	412	14	62	3,226	91	69	5,214
Upland Longleaf Pine Woodland	2,443	25,673	20,096	651	1,069	2,487	964	53,383
Water	4	6	12	17	7	9		54
Wet Pine Savanna and Flatwoods	6,135	50,760	20,993	318	4,318	6,530	686	89,842
Total	28,115	104,376	49,102	2,533	32,858	37,398	3,098	257,479

Dry and Dry Mesic Oak Forests and Mesic Slope Forests

Key Ecosystem Characteristics

Relative Ecosystem Abundance and Condition. Both dry and dry-mesic oak forests and mesic slope forests are relatively uncommon on the Forest, and would have historically been limited in distribution to fire-sheltered areas such as slopes adjacent to river terraces, islands in swamps, or on upper terraces adjacent to streams within dissected landscapes, as fire is naturally infrequent in these ecosystems (Natureserve 2012). The 1996 revised Forest plan contained an objective to identify and maintain calcareous mesic forests, and several examples of mesic slope forests are influenced by marl or calcareous geology (McMillan et al. 2001) and were addressed as natural areas in the 1996 revised plan (Everett 2012; Porcher 1995). Mesic slope forests (also known as Southern mixed hardwood forests) occur on slopes or river terraces near the Santee River and Echaw Creek, Awendaw Creek, and within dissected landscapes near Nicholson, Huger, and Turkey Creeks. Simon and Hayden (2013) estimated 214 acres in mesic slope forests in their 1st approximation, but the Forest vegetation database shows 164 acres in beech-magnolia or sugar maple-beech, and the rare community coverage (internal GIS database) includes 11 sites in calcareous mesic hardwood or 380 acres.

The 1996 revised plan emphasized mast-producing hardwoods in management area 27, and contained a Forestwide objective to have 48,000 acres (20 percent of forested acres) typed and managed as potential hard mast-producing hardwoods in the next 10 years. The 1996 FEIS (page III-40) stated that mast-producing hardwood occurred on less than 13 percent of the forested acres. The current forest vegetation database shows 3,022 acres in upland hardwood (Table 2-11) including 2,606 acres in upland oak or oak-pine, and 28,115 in bottomland hardwood or mixed with pine (which includes 14,027 acres in a bottomland hardwood oak or oak-pine). The two combined are 31,213 in upland or bottomland hardwood (12.1 percent of forested acres) or 17,049 acres with oak (6.6 percent of forested acres), below the 1996 Forestwide objective (48,000 acres) for mast-producing hardwoods.

Table 2-12. Percent of stands typed and managed as potential hard-mast producing hardwoods, as a percent of total forested acres

Ecological System	1996	2013
Upland Dry-Mesic Oak		1.0
Bottomland Hardwood Oak Forests		5.4
Total	**<13**	**6.6**

The 2011 Annual Monitoring Report emphasized mixed pine/hardwood types and did not specifically address hard-mast producing species, though monitoring questions address an objective of 30 percent of dominant and codominant canopy classes in mast-producing hardwoods within management area 27. Several oaks can occur as components of upland longleaf woodlands (turkey oak, runner oak, blackjack oak, bluejack oak), nonriverine swamp forests, blackwater stream and river forests, and mesic forests, but may not be abundant enough in the canopy to be typed in the Forest Service vegetation database. Simon and Hayden (2013) estimated potential for just 885 acres of dry and dry-mesic oak forests, though of that acreage 54 percent is dominated by loblolly pine or mixtures with hardwoods, with no mention of oak species.

Structural Diversity and NRV. Most natural disturbances have led to small gap openings within these ecological systems, though oak regeneration can be problematic (Johnson 1979; Collins

and Battaglia 2008). Table 2-13 shows a comparison of our ecological departure in regard to the structure of these ecosystems structural classes for the upland hardwood ecosystems, in comparison to conditions described in Atlantic Coastal Plain Dry and Dry-Mesic Oak Forests and Atlantic Coastal Plain Mesic Hardwood Forest biophysical settings models from ANDFIRE (2006). This suggests that our upland hardwood forests are moderately departed in structure compared to reference conditions, with a relatively low percentage in late successional open conditions.

Table 2-13. Ecological departure rankings for upland hardwood ecosystems on the Forest, where low=0–33%, medium=34–66%, and high=67–100% levels of departure

Eco-logical System	Early-Class A		Mid-Closed		Mid-Open		Late-Closed		Late-Open		Eco-logical Depar-ture
	Current	Predicted	Current	Predicted	Current	Predicted	Current	Predicted	Current	Predicted	
Dry and Dry-Mesic Oak	2	11	28	17	4	37	54	12	9	23	56
Mesic Slope Forest	0	10	74	35	2	15	23	30	1	10	39

Old Growth. The forest vegetation database shows 939 acres in upland hardwood (≥100 years) including 739 acres in upland oak or oak-pine and no mesic slope forests meeting the age criteria.

Stressors and Threats

Mesic slope and dry and dry-mesic oak forests are threatened by nonnative invasive plant species, dense loblolly pine plantation forestry which promote loblolly pine, and in some cases, fire regimes which are too frequent.

Too frequent fire regimes and overly dense canopies of loblolly pine can threaten hardwood forests. Approximately 75 percent of the modeled dry and dry-mesic oak acres have been prescribed burned three or more times between 2005–2012 (Table 2-7) which is a higher frequency than one would predict under natural disturbance regimes (LANDFIRE predicts a 5- to 10-year-return interval for dry mesic oak forests, and a 35-year interval for mesic slop forests). Several of our modeled hardwood stands and mesic slope forests are dominated by loblolly pine, or have more loblolly pine than existed prior to European settlement (LANDFIRE Biophysical Setting Models, Atlantic Coastal Plain Dry and Dry-Mesic Oak Forest, and Atlantic Coastal Plain Mesic Hardwood Forest 2006). Conner (2011) notes that severe droughts in more upland areas have caused mortality of oaks and hickories in many states, but observed very little mortality of oaks at his study sites in South Carolina.

Forested Wetlands

Note: Forested wetlands include blackwater stream floodplain and blackwater river floodplain forest, large river floodplain forests, tidal wooded swamp forests, nonriverine swamp and wet hardwood forests, and nonriverine basin swamp forests.

Key Ecosystem Characteristics

Relative Ecosystem Abundance and Condition. The composition, structure, and function of forested wetlands were not well addressed in the 1996 revised Forest plan. On the Francis Marion National Forest, forested wetlands conservatively occupy 118,730 acres or 45.8 percent of forested acres (based on ecological modeling). See Natureserve (Ecological Systems of

Francis Marion National Forest; 1 November 2012) for a more complete description of ecological systems containing forested wetlands which differ in composition, structure, and natural disturbance dynamics.

Several forested wetland ecosystems occur on the Francis Marion National Forest, including blackwater stream floodplain and blackwater river floodplain forests, large river floodplain forests, tidal wooded swamp forests, nonriverine swamp and wet hardwood forests, and nonriverine basin swamp forests. Forested wetlands support a high density and diversity of flora and fauna, help protect the quality of water and habitat in adjacent streams, and serve as flood water storage areas.

The Forest Vegetation database (Table 2-11) shows bald and pond cypress as the most dominant forest types (22 percent), followed by loblolly pine or mixtures with non-mast producing hardwoods (21.2 percent), pond pine and bay vegetation (20.1 percent), bottomland hardwoods including oak species (15.9 percent), longleaf pine and mixtures (6 percent), and upland hardwoods including oak (1 percent). The majority of our forested wetlands are classified as nonriverine swamps, which occur on poorly drained, organic, or mineral soil flats and are saturated by rainfall and seasonally high water tables without the influence of river or tidal flooding. The lower strata have affinities with pocossin or baygall systems rather than river floodplain systems, which have affinities with the canopy, and differ from pocossins in being relatively nutrient rich (Richardson and Gibbons 1993). A wetter group has communities with bald or pond cypress and swamp gum, and a drier group is associated with bottomland oak species. The Southeast GAP project [http://www.basic.ncsu.edu/segap/] from 1999–2001 imagery, predicted that there were 48,454 acres of nonriverine swamps on the Forest, with 35 percent occupied by the drier, oak-dominated type.

Flooding and Hydrology. Forested wetlands can be quite variable depending on flooding regime, and whether they have been exposed to prescribed fire. Low areas having long hydroperiods and areas protected from the spread of prescribed fire by streams, backswamps, and oxbows were virtually fire free (LandFire Biophysical Settings Model–Gulf and Atlantic Coastal Plain Small Stream Riparian Systems). Many of our forested wetlands were ditched and drained for the culture of inland rice prior to the end of the Revolutionary War (Porcher and Rayner 2001), and channeling and ditching for road infrastructure, as well as industrial logging and high-grading of bald cypress from forested wetlands in South Carolina, were common practices at the turn of the century (Hester 1997; Conner et al. 2011). Salt water intrusion associated with Hurricane storm surges and as predicted by climate change models are likely to impact species associated with tidal forested wetlands in the future, particularly bald cypress (Krauss et al. 2009).

Fire Regime. Fire would have occurred relatively infrequently in nonriverine swamp systems, tidal wooded swamps, and large floodplains, but would have played a role in shaping associated ecosystem, particularly when associated with longleaf ecosystems. Indicators that fire played a role in maintaining these ecosystems include the presence of native cane (*Arundinaria tecta*), spruce pine, and pond pine. Fire likely occurred at a frequency ranging from about 3 to 8 years in streamside hardwood/canebrake or pine, to 25 years or more in hardwood litter. Table 2-7 suggests 31 percent of our nonriverine swamps systems and 54 percent of our tidal wooded swamps were prescribed burned three or more times, between 2005–2012, though this may overestimate the actual burn acres within the unit, since acres burned are calculated for entire landscape burn blocks, regardless of whether they burned or not.

Vegetation changes in southeastern peatlands, marshes and swamps along gradients of burning frequency and depth of organic soil (Frost 1995). On moderately fertile sites, prescribed burning on a 1- to 3-year basis can result in open bogs with low shrubs, pitcher plants, grasses and sedges, intermediate burns can increase the incidence of native canebrakes, and burning on a 25 year or higher rotation or greater can result in forested mosaics with cypress, pond pine, loblolly pine, swamp gum, bay forests, and pocossin-like vegetation. He suggests that forested wetlands have replaced peatland and fluvial canebrakes on these forested wetland sites which originally experienced landscape-scale fires. Sharitz and Gibbons (1982) note that poorly drained interstream areas of the Coastal Plain were historically covered by broadleaf swamp forests, but fires by Native Americans may have changed many swamp forests to pocossins.

Structural Diversity and NRV. Many forested wetlands exist naturally as multi-aged older forests driven by gap-phase regeneration (Natureserve 2012), though there is significant variation in composition with hydrology, landscape position, and past land management. The following LANDFIRE Biophysical Settings models (2006) were consulted in this analysis: Gulf and Atlantic Coastal Plain Small Stream Riparian Systems; Gulf and Atlantic Coastal Plain Floodplain Systems, and Gulf and Atlantic Coastal Plain Swamp Systems. Ecological departure rankings suggest that small blackwater river and stream floodplain forests, tidal wooded swamps, and nonriverine basin swamps on the Francis Marion National Forest have low levels of ecological departure in regard to structure, but large river floodplains and nonriverine and nonriverine swamp and wet hardwood forests are moderately departed. Small blackwater river and stream floodplain forests have much fewer late successional open forests and more late successional closed forests compared to reference conditions. Large river floodplain forests had a much higher percentage of late-successional closed forests and fewer early successional forests than predicted.

The Gulf and Atlantic Coastal Plain Swamp Forest Biophysical Setting models were used as a comparison model for Non-riverine Swamp and Hardwood Ecosystems, but this model predicts a very disturbance regime which would result in very little open forest. A model which addresses the natural disturbance variation in nonriverine swamp forests is needed.

Table 2-14. Structural ecological departure rankings for forested wetlands on the national forest, where low=0–33%, medium=34–66%, and high=67–100% levels of departure

Eco-logical System	Early-Class A		Mid-Closed		Mid-Open		Late-Closed		Late-Open		Eco-logical Depar-ture
	Current	Predicted	Current	Predicted	Current	Predicted	Current	Predicted	Current	Predicted	
Small Blackwater River and Stream Floodplain Forests	1	10	29	25	2	5	65	40	2	20	30
Large River Floodplain Forest	1	21	3	31	0	0	89	28	4	20	64
Tidal Wooded Swamp	3	10	17	17	1	0	76	73	2	0	7
Nonriverine Basin Swamp	0	10	3	17	0	0	97	73	0	0	24
Nonriverine Swamp and Wet Hardwood Forest[1]	7	10	45	17	8	0	35	73	3	0	41

[1] The Gulf and Atlantic Coastal Plain Swamp Systems BpS model was referred to because no other model was available.

Old Growth Forests. Based on analysis of age data in FSVEG, approximately 2,784 acres (7.8 percent) of these forests are ≥110 years, and 13,276 acres of swamp forests (which include nonriverine and basin swamps) are ≥100 years. Bald cypress the dominant tree is very long-lived, sometimes approaching 1,200 years (USDA Forest Service 1997).

Table 2-15. Possible old growth forested wetlands

	Suitable Lands >100 years	Unsuitable Lands	≥110 years	≥100 years
	1996 FEIS	1996 FEIS	2013	2013
Sweetbay-Swamp Tupelo-Red Maple	0	276	1,286	5,030
Bottomland Hardwood	897	1,816	3,144	6,557
Swamp Hardwood	2,933	12,334	4,230	13,276
Total	**3,830**	**14,426**	**8,660**	**24,864**

Stressors and Threats

Nonnative Invasive Species. Japanese climbing fern, Chinese tallow, feral hogs, and laurel wilt pose the greatest threats to forested wetlands on the Forest. Due to their relative inaccessibility for inventory, monitoring, and treatment, invasive species are likely to increase in forested wetlands in the future, though forest management activities, which provide microsites for possible invasion, are likely to be limited.

Dense Canopies of Loblolly Pine. Although loblolly pine can be a natural component of these ecosystems, following Hurricane Hugo areas experiencing the greatest increase in loblolly pine were wetter sites associated with bottomland hardwoods, as well as upland sites where loblolly outgrew hardwood sprouts and saplings (FEIS, page III-27), and high tree densities could draw

down the water table. Nonriverine swamps contain the highest proportion of loblolly pine, sometimes with hardwoods other than oak (23,130 acres or 29 percent of this type). Dense canopies of loblolly pine will use more water than hardwood forests, and thereby draw down the water table compared to reference conditions.

Diking, Ditching, or Rutting of Sensitive Soils. Globally wetlands are threatened by hydrologic modifications, development, and conversion to agricultural production. At the time of European settlement, it is estimated that approximately 80 million hectares of forested freshwater wetlands existed in the coterminous United States, though draining and clearing of forested wetlands for agriculture beginning in the mid-1800s, accounts for at least 87 percent of wetland loss (Journal of the Society of Wetland Scientists 1989). The Francis Marion National has much evidence of diking, ditching and rutting of sensitive soils when wet, which can cause irreversible modifications in hydrologic function.

Sea-level rise will threaten these ecosystems in the future. Populations of bald cypress may be particularly vulnerable to future changes in climate including sea-level rise.

Peatland Pocosin and Canebrakes, and Streamhead Seepage Swamp, Pocosin, and Baygalls

Key Ecosystem Characteristics

Relative Ecosystem Abundance and Condition. Atlantic Coastal Plain Peatland Pocosin and Canebrakes are evergreen shrub-dominated ecosystems, where the accumulation of organic matter exceeds decomposition, resulting in the accumulation of up to 10 feet or more of peat over a period of decades. Examples of this ecological system occur in broad wetland areas which include some areas on histosol (organic) soils, including peat filled Carolina bays (Little Ocean Bay, Big Ocean Bay, Pamlico soil series), but is more often found on wet sandy soils on poorly drained flats, and also along drainages that have been subjected to wildland fire (Natureserve 2012). Streamhead seepage swamp, pocossin, and baygall occur within dissected landscapes on sites saturated with shallow groundwater. For additional information on the structure, and composition, and function of these ecosystems, see Natureserve (2012), Richardson and Gibbons (1993), and Sharitz and Gibbons (1982).

The 1996 revised Forest plan contained an objective to "[I]dentify and maintain existing acreage in ...bay swamp pocosin,..". Select seepage bogs and portions of a few pocossins were included as designated botanical areas in the 1996 revised plan (Little Ocean Bay, Morgan Creek Bog, and Halfway Creek Pocossin, for example). Sweet pitcher plant (*Sarracenia rubra*) was identified as a management indicator species, a carnivorous perennial plant of the bogs and moist soil margins of pocossins, bays and cypress-tupelo ponds of the coastal plain.

Based on LiDAR, Simon and Hayden (2013) predict a relatively modest acreage in peatland pocosin and canebrakes (2,027 acres), pocossin vegetation in Carolina bays (252 acres), and streamhead seepage swamp, pocosin, and baygalls (76 acres). There is a fair amount of uncertainty in predicting streamhead seepage swamp, pocossin, and baygalls, and more work is required to reduce the uncertainty. In 2013 use of LIDAR and soils suggests that raised peat accumulation typical of natural pocossins is uncommon on the Forest. Vegetation typical of pocossins may be found in association with nonriverine swamp forest or depression pond ecotones (not to be addressed here), and can also contain abundant pond pine.

Monitoring or designated botanical areas and associated at-risk species, including sweet pitcher plant, suggests that there have been declines in a subset of seepage bogs and pocossin ecotones,

due to succession, lack of frequent fire, feral hogs, and poaching of associated pitcher plants (Everett 2012).

Fire Regime. Prescribed fire and flooding are the most important processes influencing the composition of these ecological systems. Natural fire return intervals for peatland pocossins are not well known, but are probably on the order of a decade or two in the wettest areas, though peripheral areas may be subject to fire as often as the surrounding vegetation burns, which may naturally have been an average of 3 years (Natureserve 2012). Openings created by prescribed fire, are important for many at-risk species. Streamhead seepage swamp, pocossin, and baygalls would have burned more frequently, particularly when imbedded within a landscape of fire-maintained vegetation. Everett (2012) recommended annual burning to restore herbaceous diversity at Morgan Creek Bog, and in pocossin ecotones.

Stressors and Threats

Feral hogs have been documented as threats, as has succession, lack of frequent or intense fire, poaching of associated pitcher plants, and diking or drainage on soils when wet potentially impacting hydrology. In the absence of prescribed fire, these ecosystems will succeed to tall pocossin, pond pine, and swamp forest ecosystems.

Carolina Bay Wetlands and Depression Ponds

Key Ecosystem Characteristics

Relative Ecosystem Abundance and Condition. The 1996 revised Forest plan contained an objective to, "[I]dentify and maintain existing acreage in pond cypress/swamp tupelo pond, and pond cypress and pine savannas…" and select Carolina bays and depression ponds were included as designated botanical areas. Bennett and Nelson (1991) identified only 30 Carolina bays in Berkeley County and 13 in Charleston County. De Steven and Harrison (2006) noted 187 natural depressions on the Forest of which nearly 50 percent were <1 acre in size. With the use of LiDAR Simon and Hayden (2013) identified 83 Carolina bays and 435 depression ponds within the Forest proclamation boundary.

Carolina bays and depression ponds are palustrine wetlands contain a variety of vegetation types depending on fire regime and flooding depth and duration. Bennett and Nelson (1991) identified nine community types in Carolina bays, including pocossins, pond cypress and swamp tupelo ponds, pond cypress savannas, and non-alluvial swamps, but in the lower coastal plain, pond cypress ponds and pond cypress savannas were most common. DeSteven (2006) found few herb-dominated depression ponds, and that most of them were forested.

Pond cypress savanna, depression ponds, limesinks, and pond cypress ponds are all vegetation types represented as designated botanical areas in the 1996 revised Forest plan, which occur within this group. Monitoring of many is threatened by successional vegetation, lack of frequent prescribed fire, feral hogs, and poaching of associated pitcher plants and orchids (Everett 2012; Glitzenstein 2012).

Landscape Connectivity and Fire Regime. Frequent prescribed fire is an important process for maintaining and restoring an herbaceous component within Carolina bays and depression ponds. Numerous depressional wetlands and Carolina bays are imbedded within Pleistocene terraces where fire would have occurred frequently, burning into the ecotones and often through the pond. Isolated wetlands and Carolina bays were historically protected from fire, and old firelines can still be seen within the ecotone. In the absence of frequent fire, particularly during periods

of drought, isolated wetlands acquire an evergreen shrub component, and both loblolly pine and swamp tupelo can become establish, shading out the herbaceous understory.

Herbaceous Understory. Carolina bays and depression ponds provide critically important habitat for at-risk plant and amphibian species and rare plant communities. Much of the biodiversity is associated with the fire-maintained ecotones (Kirkman et al. 1998), but also as open water breeding habitat for amphibians. Pond cypress savanna vegetation is likely the most diverse (Gramling 2003; Bennett and Nelson 1991). Many at-risk species are associated with herbaceous understories, yet successional dynamics are poorly understood (Natureserve 2012). Climate change could lead to more forested and fewer herbaceous depressions, although the potential for more fires might be a counteracting force (De Steven and Toner 2004). Everett (2012) recommends annual burning, to restore herbaceous diversity along ecotones, interiors, and sand rims.

Stressors and Threats

Some of our cypress savannas and other depressions and Carolina bays on the Forest, particularly in the wildland-urban interface, have declined due to a combination of lack of frequent prescribed fire and drought leading to growth of a high density of tree species, including loblolly pine, which further draws down the water table and outcompetes herbaceous ground cover (Everett 2012; Glitzenstein 2012). Everett (2012) and Glitzenstein (2012) note feral hog damage in many or our depression ponds and Carolina bays associated with at-risk plants, and Chinese tallow has been observed within some of our depression ponds. With changes in climate, annual temperature and drought frequency are expected to increase which could favor succession to forests in these ponds (Stroh et al. 2008). Other threats to depression ponds and Carolina bays on the Forest include illegal all-terrain vehicle use in proximity to Halfway Creek Road.

Of 2,651 Carolina bays identified by Nelson and Bennett, the majority (15 percent) were in Horry County, and of those sampled, 97 percent exhibited some type of disturbance. At the landscape scale, Carolina bays and depression ponds that receive surface water and ground water from surrounding uplands may be most sensitive to land disturbances and climate change (Lu et al. 2009).

Maritime Forests, Saltwater and Freshwater Marsh

Key Ecosystem Characteristics

Relative Ecosystem Abundance and Condition. The 1996 revised Forest plan contained an objective to, "[I]dentify and maintain existing acreage in maritime forest. Only a coastal fringe of maritime forest is identified through current mapping efforts in 2013 (416 acres), and both freshwater marsh and saltwater marsh were relatively uncommon (0 and 2,568 acres). Salt marsh and freshwater marsh ecosystems were not addressed in the 1996 revised Forest plan. Several areas containing maritime fringe and salt marsh have been acquired by the Forest since 1996 in the vicinity of Guerin Bridge Road, much in bedded loblolly pine (Porcher 2005). One maritime forest containing habitat for the sensitive *Agrimonia incisa* was included as a designated botanical area, though monitoring suggests the site is threatened by dense canopies of loblolly pine (Everett 2012).

Structural Diversity and NRV. We compared vegetation classes from the biophysical settings models (Biophysical Setting 5813610–Central Atlantic Coastal Plain Maritime Forest), including age class and structural breakouts to define each class, to those found on the Forest using Forest FS VEG even-aged age class data, and LIDAR shade data to quantify canopy opening. Maritime

forests on the Forest have a higher percentage of early succession and in mid-closed conditions and less in late-closed conditions than would be expected compared to reference. This is in part due to the severity of Hurricane Hugo which relatively recently impacted the Forest.

Table 2-16. Structural ecological departure rankings for maritime forests on the national forest, where low=0–33%, medium=34–66%, and high=67–100% levels of departure

Eco-logical System	Early-Class A		Mid-Closed		Mid-Open		Late-Closed		Late-Open		Eco-logical Depar-ture
	Current	Predicted	Current	Predicted	Current	Predicted	Current	Predicted	Current	Predicted	
Maritime Forest	20	7	45	22	8	7	0	13	12	51	52

Old Growth. There is no maritime forest that qualifies as possible old growth.

Stressors and Threats

Many of our maritime fringe forests are threatened by past management practices which included ditching and diking for the production of rice (Porcher 2005), planting of loblolly pine, nonnative invasive species, and hurricanes. In the future, they are the most likely to be threatened by sea-level rise and climate change.

2.1.1.7 Information Needs

Future trends in existing ecosystems and in their condition, including herbaceous understory communities.

Refinements of LANDFIRE biophysical models would be useful which address old growth and nonriverine swamp forests vegetation, relevant to ecosystems on the Francis Marion National Forest.

Suitable methods could be identified for restoring wet pine savanna and flatwoods, mesic slope forests, dry and dry mesic oak forests, maritime forests, depression ponds, and Carolina bays.

Monitoring indices for assessing ecosystem integrity of all our ecosystems are needed which are practical, reliable, and address trends in key ecosystem characteristics.

2.1.1.8 Levels of Uncertainty

The ecological model used in this analysis is a first draft. Monitoring information in regard to the condition of terrestrial ecosystems is generally very limited.

2.1.2 Aquatic Ecosystems

2.1.2.1 Preliminary Findings

►**The 1996 Francis Marion Forest Plan has limited direction on the viability of aquatic species and communities, aquatic habitat, and riparian area management.** In addition, the plan allows the removal of wood from streams through South Carolina's Best Management Practices for Forestry (2003). Most streams and riparian areas were not recognized as aquatic ecosystems and were included in management area 27, which is suitable for timber management. The 2012 Planning Rule requires better direction associated with aquatic ecosystems.

►**In a recent inventory of prescribed burning effects on large wood loading on the Forest, data revealed that in over 20 kilometers of headwater stream sections, the largest, most**

stable instream wood was deficient (USDA SRS Center for Aquatic Technology Transfer, Draft). Instream habitat diversity is dependent on large wood input from the riparian area.

►**The National Hydrography Database represents far less stream miles than the new remote sensing technology of LIDAR.** The LIDAR mapping for the Forest is somewhat inconsistent due to the lack of road culvert location data and other stream barriers. Existing riparian mapping is based on soil indicators and 29-acre catchment areas and may exclude some headwater streams. Designation of riparian areas, acres of riparian area, and density of roads within riparian areas are likely to change as a more accurate stream layer map becomes available.

►**Threats to aquatic habitats include stream flow modification, sedimentation and water quality modification from roads and trails, dams, drought and forestry management practices.**

►**There has been very little change in fish diversity in headwater streams across the Forest over the sampling years.** Headwater stream sampling was conducted in 1993 and repeated five times from 2002 to 2010 across ten watersheds on the Forest. Thirty-five species were captured in the 1993 inventory. Thirty-seven species were captured in the 2002 to 2010 samples. Fish abundance recorded in 2010 was noticeably less than in previous inventory years, most likely due to drought conditions (Krause and Roghair 2010).

►**Existing population conditions and trends are unknown for crayfish and mollusk.** Crayfish and mollusk surveys were conducted across all Forest watersheds in 2011. A total of 84 streams was sampled for crayfish. Crayfish were collected in 72 of these streams. A total of 38 streams was sampled for mollusk species. Mollusk species were found in 26 streams. Thirteen mussel species, three clam species and eight snail species were collected in 2011. The Catena Group report (2011) concluded that mussel diversity was low within stream reaches on the Forest, which is considered typical of tannic, swamp water streams along the Atlantic Slope. However, a few streams characterized as having wide, natural riparian buffers contained very high densities of mussels.

►**Of the 28 aquatic nuisance species listed by the South Carolina Aquatic Invasive Species Management Plan (2008), 8 are known to occur on the Forest. SCDNR reports that there has been an increase in plant and animal nuisance species in freshwater and marine habitats and are already impacting native animals and their habitats.** The SCDNR climate report (http://www.dnr.sc.gov/pubs/CCINatResReport.pdf), also states that as climate changes, an increasing number of nuisance species likely will migrate to South Carolina. In the event that water temperatures were to increase in the State, existing nuisance species that are sensitive to cooler water temperatures may have better survival rates and proliferate.

2.1.2.2 Direction in the 1996 Francis Marion Forest Plan

Forest Wide Goal G-7 Protect and Manage Habitat for Sustainable Populations of Native Wildlife (page 1-2, Forest plan) “The Francis Marion is home to many different species of wildlife. Our goal is to provide for wildlife resource needs while servicing public interests and uses through habitat management that supports viable populations of all existing native wildlife species and where opportunities exist, to enhance habitat for populations of animals that are commonly viewed, photographed, hunted or fished.”

Forest Desired Future Condition, Soil and Water (page1-5, Forest plan) “The streams, ponds, wetlands, and riparian areas of the Forest reflect healthy, functioning ecosystems. Natural woody

debris is found in streams. This debris serves an important ecological function. It maintains channel stability, stores and routes sediment, and provides habitat requirements for anadromous and resident fish. Riparian areas with diverse stands of trees provide streamside vegetation that helps to maintain stream temperatures needed for fish habitat. High water quality is maintained and in some cases improved. Streams have little sediment because of careful management of timber harvest activities, roads, and similar soil disturbing activities. Aquatic ecosystems remain intact and serve as habitat for a variety of fish and invertebrates. Wetlands are protected and continue to serve as vital functioning ecosytems".

Forest Desired Future Condition, Wildlife and Fisheries (page 1-7, Forest plan) "High-quality aquatic habitat is maintained. Streams and ponds are relatively free from sediment. Tessellated darters and speckled madtoms are common. High populations of popular game fish such as the largemouth bass and redbreast sunfish ensure ample fishing opportunities. Both anadromous and resident fish populations are thriving."

Forest Objective O-13 (page 2-2, Forest plan) "Maintain or expand existing proposed, endangered, threatened and sensitive (PETS), and Management Indicator Species and communities (MIS)."

Forest Objective O-15 (page 2-2, Forest plan) "On managed Forest ponds, sustain 200-300 pounds/acre of bass and bluegill at a ratio of 1:6 bass to bluegill."

Forest Standards and Guidelines, Insects and Diseases, FW-70 (R8-SPB) (page 3-7, Forest plan) "Riparian ecosystems that encompass floodplains and wetlands will receive appropriate protection. As a minimum, riparian areas will extend 100 feet from the edge of all perennial streams and other perennial water bodies, including lakes. Site investigations to identify riparian areas and floodplains will consider the soil and plant characteristics of the site, and will be guided by appropriate Forest Service direction and state requirements. Roads that cross riparian areas will be stabilized with rip-rap, vegetative establishment, or other appropriate methods."

Forest Standards and Guidelines, Soil and Water, FW-97 (R8-VM) (page 3-10, Forest plan) "Mechanical equipment is not allowed in any defined stream channel except to cross at designated points, and may not expose more than 10 percent mineral soil in filter strips along lakes, perennial or intermittent springs and streams, wetlands, or water-source seeps. The strip's width in feet is at least 30 plus 1.5 times the percent slope. Soil and debris are not deposited in lakes, streams, wetlands, springs, or seeps."

Forest Standards and Guidelines, Soil and Water, FW-99 (R8-VM) (page 3-10, Forest plan) "Channel stability of perennial and intermittent streams is protected by retaining all woody understory vegetation within at least 5 feet of the bank and by keeping slash accumulations out of the stream."

Forest Standards and Guidelines, Soil and Water, FW-100 (R8-VM) (page 3-10, Forest plan) "No herbicide is aerially applied within 100 horizontal feet, nor ground-applied within 30 horizontal feet, of lakes, wetlands, or perennial or intermittent springs and streams. No herbicide is applied within 100 horizontal feet of any public or domestic water source. Selective treatments (which require added site-specific analysis and use of aquatic-labeled herbicides) may occur within these buffers only to prevent significant environmental damage such as noxious weed infestations. Buffers are clearly marked before treatment so applicators can easily see and avoid them."

Forest Standards and Guidelines, Soil and Water, FW-101 (page 3-10, Forest plan) "Avoid construction (roads, trails, recreational sites, etc.) in floodplains and wetlands whenever there is a practical alternative."

Forest Standards and Guidelines, Soil and Water, FW-107 (page 3-11, Forest plan) "Avoid direct application of fertilizer to water bodies including streams (unless prescribed for wildlife habitat improvement)."

Forest Standards and Guidelines, Soil and Water, FW-109 (R8-VM) (page 3-11, Forest plan) "In each project, water quality is protected from nonpoint-source pollution through use of preventive "best management practices" (BMP's). Implementation of BMP's, monitoring and evaluation of their application and effectiveness, and adjustment of practices as needed are done to protect beneficial water uses and comply with State water quality laws. BMP's are applied to all activities. In each project, site-specific conditions must be assessed, and the BMP's needed to meet state water quality standards must be employed."

Forest Standards and Guidelines, Soil and Water, FW-115 (page 3-11, Forest plan) "Maintain a near continuous (unbroken) canopy of vegetation for 30 feet on both sides of perennial streams and water bodies. Resource management activities may be implemented if riparian conditions are maintained or improved and the natural supply of large woody debris into the streams and water bodies is not impaired. Timber harvest methods that ensure a residual basal area of 50 percent can be utilized when managing a zone from 40-70 feet on perennial streams and water bodies and 40 feet on either side of intermittent streams. Use of mechanical equipment will be limited to protect the riparian and water resources. Additional zones adjacent to riparian areas and ephemeral streams can be established as necessary to meet site specific conditions and management objectives. The width of the zones will depend on slope, vegetation and soil conditions. These zones will be managed to protect soil and water resources by the types of management activities in these zones and controlling the use of equipment."

Forest Standards and Guidelines, Wildlife and Fisheries, FW-154 (page 3-16, Forest plan) "Lime and fertilize managed ponds based on established procedures to meet the management indicator objectives for fisheries."

Management Area Prescription 27 (page 4-13, Forest plan) "This area includes portions of the loamy ridges/flats, river/creek bottoms and swampy flats. This management area includes areas of the Forest containing a network of creeks, streams and transitional areas where there is a potential for developing mixed stands and high quality mast and timber producing hardwoods."

2.1.2.3 Aquatic Ecosystems on the Francis Marion National Forest

Aquatic ecological systems are stream and lake networks representing a range of areas with distinct geomorphological patterns tied together by similar environmental processes such as hydrologic, nutrient, and temperature regimes. They form a distinct unit or hydrography map. Freshwater ecosystem attributes such as water-body size, hydrological and temperature regime, chemistry, drainage network position, local connectivity, elevation, and gradient can result in distinct aquatic assemblages and population dynamics between and within streams and lakes (Palmer et al. 2005). Streams and rivers are considered together as an aquatic ecosystem for this analysis given the similarity of the hydrology, water quality, habitat and biota across 6th-level hydrological watersheds on the Forest. Lentic systems are considered as a separate aquatic ecosystem for this analysis.

Streams and Rivers

Coastal plain stream systems consist of rivers that often originate in the Blue Ridge or Upper Piedmont and blackwater streams that originate in the Coastal Plain or Lower Piedmont (McDougal et al. 2001). Tannic stained blackwater streams are the most common stream type on the Francis Marion National Forest and originate in the Coastal Plain, primarily on the Forest itself. The Santee River borders the north end of the Forest and originates in the mountain region of South Carolina. The West Fork Cooper River is adjacent to the southern border of the Forest and headwaters partially on the Forest but completely in the Coastal Plain. For this assessment, streams and rivers include fresh, tidal and brackish flowing waters. Streams and rivers are in the process of being mapped and it is possible that watershed boundaries may be adjusted through the mapping process.

Lentic Systems

Lentic systems are water bodies of non-flowing water. On the Forest, aquatic species inhabit ponds, swamps, ditches, springs, wetlands, marshes, Carolina bays, sloughs, and oxbows. These include fresh and brackish waters and can be influenced by flooding and tidal waters. Ponds are primarily borrow pits excavated for road construction that are stocked and managed for recreational fishing opportunities. There are 15 recreational fishing ponds on the Francis Marion consisting of a total of 41 acres. Ditches are also man made and occur across the Forest, but are primarily located along roads. Crayfish species utilize the road ditches as well as some fishes, such as pygmy sunfish species. The remaining lentic systems are nested within the various terrestrial ecosystems (see section 2.1.1 “Terrestrial Ecosystems”).

2.1.2.4 Habitat Structure

Coastal Plain blackwater streams are low-gradient warm water streams consisting primarily of pool habitat and very little riffle habitat. They are tannic stained and generally exhibit very slow flows, although larger streams may have moderate currents. These stream systems lack the turbidity of systems that originate outside the Coastal Plain area. Stream substrate is primarily sand or organic soils prone to displacement during storms. There is very little rock substrate in these streams, therefore logs and debris piles are essential for aquatic fauna habitat. Wood is an important component to instream habitat for aquatic species refuge, foraging areas and food and also hydrological functions (McDougal et al. 2001). Most coastal plain streams that receive ample sunlight are well vegetated with aquatic macrophytes. These streams are often associated with lentic backwaters and swamps (http://www.dnr.sc.gov/cwcs/pdf/habitat/CoastalPlainAquatics.pdf). The Santee River is classified as a brown-water stream with turbid waters and generally more sediments. Flows vary in the river associated with hydroelectric dam management upstream of Forest lands and downstream from tidal cycles. Streams are primarily freshwater, but some tributary streams of the Santee, West Cooper, and Wando rivers contain brackish waters during tidal cycles. Streams and rivers on the Forest typically have access to their floodplain, but many have been affected by channelization, ditching, and dikes that limit or control flooding and water movement. Floodplains are discussed in more detail in section 2.4 “Water Resources and Quality”.

Recreational fishing ponds consist of sand and organic substrates and aquatic vegetation. These ponds were formed from old borrow pits created for road construction materials. Pond habitat is enhanced manually with brush and trees. The ponds are periodically limed to improve the water quality associated with aquatic productivity. Ditches contain vegetation which provides cover and foraging areas for a variety of aquatic species. Road ditches are maintained through maintenance which diminishes the vegetative habitat for short periods of time.

2.1.2.5 Habitat Connectivity

The physical structure of aquatic habitats is a major factor in the continuity between and heterogeneity within aquatic habitats that supports the local diversity of fauna and flora. Connectivity of streams with rivers and of streams and rivers with floodplains are a basic characteristic of aquatic systems that is fragmented by such barriers as dams and inadequate road and trail crossings. The physical configuration of streams and rivers provides a rich diversity of habitats such as banks, riffles, and deep pools where fish and other fauna feed, rest, and breed. Alterations to the hydrologic and energy regimes of streams or rivers affect the physical structure of aquatic habitats (Palmer et al. 2005).

The Santee Dam hinders the migrations of native anadromous fish to their historic spawning grounds in the piedmont. These include shad, striped bass, and sturgeon. In addition to the large dam on the Santee River, there are numerous smaller dams and dikes throughout Forest watersheds that are barriers to fish movement. These smaller dams also create impoundments in natural stream systems. This results in a loss of habitat through the conversion of lotic habitat to lentic habitat, which favors competitive and often predacious species like largemouth bass and other centrarchids. Stream habitat below impoundments can be impacted through altered hydrology and water temperatures, modified stream channel morphology, and increased erosion and sedimentation. These impacts reduce suitable habitat for native aquatic fauna (http://www.dnr.sc.gov/cwcs/pdf/habitat/CoastalPlainAquatics.pdf). Dams are present in each of the 28 subwatersheds that contain Forest Service land. The number of dams range from 1 to 216 in a single watershed with the majority of watersheds containing more than 10 structures (Francis Marion and Sumter National Forests GIS 2013).

Hydrological modifications impacting stream systems on the Forest also include road and trail crossings. Roads act as dikes and block or alter the natural flow of floodplains and swamps. Aquatic passage exists with road bridge crossings, but no aquatic organism passage surveys have been conducted on the over 500 miles of Forest Service roads on the Forest. Additional crossings occur on private lands and on over 200 miles of state and Federal roads in Forest watersheds. Connectivity may occur between streams during periods of rain through road ditches. Connectivity is greatest during high rainfall years when the Forest floods. Road density ranged from 0.55 to 5.97 miles per square mile; with four watersheds containing less than two road miles per square mile and 24 watersheds having greater than two road miles per square mile. Eight watersheds contained greater than three road miles per square mile. Within 100 foot riparian areas, four watersheds had less than one percent in total acres of road and 24 watersheds had greater than 1 percent in total acres of road. Riparian area road acres ranged from 0.58 percent to 4.27 percent.

Recreational fishing ponds are completely contained with no connection to each other or to stream systems. Many road ditches connect streams. These ditches are often deep and wide and when filled with water may provide a conduit for aquatic species movement from one stream to another.

2.1.2.6 Threats and Stresses

A threat is an unacceptable alteration to any of the key ecological attributes necessary to support aquatic system function (hydrological and energy regime, physical habitat structure, water quality and biota). A stress is that activity leading to the unacceptable alteration such as damming of rivers and streams, and excessive siltation and contaminants from practices associated with development, agriculture, forestry and mining. A single threat can have multiple stresses (Palmer et al. 2005). Threats and stresses are addressed in relation to habitat and species for this analysis.

Stream flow modification, sedimentation, and water chemistry modification are the most prevalent threats to aquatic ecosystems on the Forest. Several stressors are present for each of those threats and discussed below.

Habitat Threats

Stream Flow Modification. Stream flow modification causes changes in the pattern of flow that is characteristic for a stream or river. Due to watershed characteristics such as slope, soil type and precipitation patterns, there is a typical season, frequency, duration, magnitude, and rate of change of water level fluctuations. Hydrologic regimes are a driving factor in aquatic ecosystems. Activities that create barriers to flow, excessive withdrawals or discharges of water, or in other ways alter the pattern of flow are threats to aquatic habitats (Palmer et al. 2005). These activities or stresses are identified as roads and trails, dams, drought, and forestry management practices for Forest aquatic systems.

Sedimentation. Siltation resulting from clearing forests, tilling soils and channelization of coastal plain streams has altered stream morphology. Modern soil conservation practices and reduced channelization have reduced those impacts, but sedimentation from nonpoint and point sources remains a significant detriment to streams today. Ground disturbance from development, agriculture, and silviculture are primary sources of erosion that lead to sedimentation in streams. Stream bank erosion due to loss of riparian areas, livestock grazing and altered hydrology also contribute to sedimentation in streams. During the past century, many streams in the coastal plain were channelized to improve drainage of croplands. The result of channelization changed many streams into straight shallow ditches with severely depressed populations of aquatic fauna (http://www.dnr.sc.gov/cwcs/pdf/habitat/CoastalPlainAquatics.pdf). Stresses identified for sedimentation on the Forest include roads and trails and forestry management practices.

Water Chemistry Modification. Good water quality is critical to the sustainability of aquatic biota. Temperature, dissolved oxygen concentration, acidity, and salinity are common attributes of natural water quality conditions that are affected by water management structures and polluted discharges. Some constituents in the water, such as sediments, heavy metals and nutrients, may occur in low levels in natural systems, but they are usually considered pollutants when concentrations rise above biologically tolerable levels. Chemicals such as pesticides, hormones, and petroleum products are not found in natural systems and their presence indicates threats to aquatic habitats from inadequate enforcement of permitted discharges and improperly managed stormwater runoff (Palmer et al. 2005).

The coastal plain has a modest amount of permitted discharges and concentrated animal feeding operations which are a significant threat to aquatic habitats. Water quality in the coastal plain at sites sampled by the South Carolina Department of Health and Environmental Control (SCDHEC) has the highest impairment rate of the four ecoregions in the state. Recreational uses were impaired at some sites sampled due to the presence of high concentrations of fecal coliform bacteria. Approximately one-fourth of streams sampled by SCDHEC within the ecoregion did not support aquatic life uses, indicating the streams do not possess sufficient water quality to maintain a balanced aquatic community of plants and animals. Mercury contamination is abundant in the coastal plain. This contamination indicates a serious threat not only to aquatic fauna but also to human health and recreational uses. Fish consumption advisories have been issued for nearly every major water body in the Coastal Plain due to mercury contamination in fish tissue sampled by SCDHEC (http://www.dnr.sc.gov/cwcs/pdf/habitat/CoastalPlainAquatics.pdf). Stresses for water chemistry modification on the Forest are identified as dams, drought, and forestry management practices.

Habitat Stresses

Roads and Trails. Roads and trails are identified as stresses for stream flow modification and sedimentation. Stream road crossings can create barriers to aquatic organism movement, effectively fragmenting linear habitat. They also can affect channel morphology and geomorphic processes, causing incision and erosion. Road crossings change the natural shape of the stream and how the stream is allowed to flow through the barrier. This has the potential to affect sediment transport and deposition and the movement and migration of aquatic species (http://ice.ucdavis.edu/waf/model/indicator/aquatic-habitat-barriers).

Roads, recreational trails, and mechanical fire lines within riparian areas and floodplains are constant sources of sediments to stream systems. Maintenance practices, undersized culverts, use of fords and rotation cycle disturbance of fire lines increase sediment input. Road density in riparian areas and in watersheds was discussed under "Habitat Connectivity."

Dams. Dams are identified as a stress for stream flow modification and water chemistry modification. Dams are discussed in this section under "Habitat Connectivity."

Drought. Drought is identified as a stress for stream flow modification and water chemistry modification. Drought in streams may be viewed as a disturbance in which water inflow, stream flow and water availability fall to extremely low levels for extended periods of time. Impacts can range from flow reduction to loss of surface water and stream connectivity. This results in loss of habitat for aquatic organisms. Other impacts may include deterioration of water quality, alteration of food sources, and changes in the strength and structure of interspecific interactions. Droughts have effects on density and diversity of aquatic communities and the ecosystem processes that support them. Organisms can avoid some drought conditions by the use of refugia such as deeper pool habitat or spring fed areas (Lake 2003). Streams on the Forest have been under the stress of summer drought over the past decade. Observations of small headwater streams include completely dry stream beds to stream beds with some amount of water in deeper pool habitats. These areas are often confined to excavated areas around bridges and culverts. With increased rainfall, aquatic organisms move back upstream as stream flows increase and connectivity is reestablished.

Water withdrawal for irrigation is a common practice in the ecoregion. With the rapidly increasing populations along the coast, demand for freshwater will increase dramatically and water withdrawal from streams and rivers as well as interbasin water transfers will be a serious threat to aquatic habitats and their natural communities (http://www.dnr.sc.gov/cwcs/pdf/habitat/CoastalPlainAquatics.pdf).

Forestry Management Practices. Forestry management practices have been identified as a stress for stream flow modification, sedimentation, and water chemistry modification. Forestry practices can impair aquatic habitat through the manipulation of riparian vegetation. Loss of canopy results in increased water temperatures that will limit the amount of available habitat for some species like striped bass (http://www.dnr.sc.gov/cwcs/pdf/habitat/CoastalPlainAquatics.pdf). Large wood, detritus and leaf litter recruitment is also compromised with the loss of canopy resulting in a decrease of instream habitat complexity and macroinvertebrate food sources. Removal of riparian vegetation and disturbance within riparian areas can lead to erosion and chemical inputs to surface and ground waters. Incompatible forestry practices also include those that convert the natural architecture, composition, and structure of riparian habitats and their watersheds to even-aged, monocultures of off-site species (Palmer et al. 2005).

Fire is used as a tool on the Forest to maintain red-cockaded woodpecker pine habitat and to reduce fuels. Streams are used a natural fire breaks and riparian areas are burned. This often leads to the charring and loss of large wood within stream channels, particularly where riparian areas are small and during drought years when streams are burned over. Impacts on canopy cover within burned riparian areas have not been assessed. Fire lines are occasionally mechanically constructed across streams and through riparian areas.

2.1.2.7 Species Threats and Stresses

The aquatic biota in a stream is a function of the habitat conditions outlined above, as well as the successful completion of life cycles and sustainable populations. Sources of stress that alter the abundance and diversity of species or the interactions among species include factors that do not necessarily directly alter aquatic habitats. For example, invasive species are a very serious threat to aquatic biota (Palmer et al. 2005).

Aquatic Nuisance Species

Introductions of nonnative species have had a significant impact on native aquatic fauna in the Coastal Plain Ecoregion. Common carp, flathead catfish, and blue catfish are established in several drainages. Flathead catfish are known to prey on bullheads, darters, shad, suckers and sunfish. Declines in native species have been observed after the introductions of flathead catfish. Common carp occur in every South Carolina drainage and are considered a pest, but their impact on native fauna is not well known. Common carp disrupt aquatic habitats by rooting around in the substrate, which uproots aquatic plants and increases turbidity and siltation. Common carp have also been shown to prey on the eggs of other fish species (http://www.dnr.sc.gov/cwcs/pdf/habitat/CoastalPlainAquatics.pdf). Grass carp are used as biological control agents for nuisance aquatic vegetation in South Carolina. This species is regulated and tested by the SCDNR as they are brought in by growers from other states. Only triploid grass carp are permitted. This insures that they are sterile and cannot reproduce if escapement occurs (South Carolina Aquatic Invasive Species Management Plan 2008). No reproducing populations of grass carp occur on the Forest, but sterile grass carp have been stocked in the past to control aquatic vegetation in recreational fishing ponds.

The Asian clam has been introduced and has widely spread throughout the United States, including South Carolina. The effects of the Asian clam on native species are not particularly well understood. Three invasive snail species (*Viviparus georgianus*, *V. purpureus*, and *Bellamya/Cipangopaludina japonica*) are present in Lakes Marion and Lake Moultrie just west of the Forest; however, their impact on native fauna is not known (http://www.dnr.sc.gov/cwcs/pdf/habitat/CoastalPlainAquatics.pdf). The island applesnail has been found in the South Carolina coastal plain, but not yet reported from the Forest. Potential impacts of introduced populations of the island applesnail are broad reaching and can even have human health implications. Because they eat such a wide range of aquatic plants, they are a potential threat to South Carolina aquatic ecosystems. Infestations can be very dense and cover large areas, causing harm to the aquatic environment by destroying native plant species and drastically affecting the food web through their ability to kill or out-compete native snail species (http://www.dnr.sc.gov/water/envaff/aquatic/snail.html).

The red swamp crayfish has been introduced to South Carolina and has been observed at several locations in the southeastern plains and coastal plain, but it is unclear how widespread it is in the State. The lack of survey work since its introduction and the difficulty distinguishing the red swamp crayfish from a native crayfish (eastern red swamp crayfish) have made it particularly difficult to determine the extent of its introduced range

(http://www.dnr.sc.gov/cwcs/pdf/habitat/CoastalPlainAquatics.pdf). It is possible that the red swamp crayfish occurs on the Forest, and it would be expected to occur in the types of habitat where the Eastern red swamp crayfish has been collected. The two are very closely related species and have similar habitat requirements. The red swamp crayfish has been introduced as an aquaculture species within the range of Eastern red swamp crayfish in South Carolina, but little is known about the distribution of escaped the red swamp crayfish populations in South Carolina (Jones and Eversole 2011).

Alligatorweed is found throughout South Carolina. It spreads rapidly by fragmentation. Alligatorweed displaces native vegetation, and disrupts navigation, recreation, and water flow by the formation of impenetrable mats. It decreases uptake for agricultural, municipal, and industrial purposes and expands human health risks with increases in mosquito breeding habitats. Alligatorweed has been documented from one recreational fishing pond on the Forest (Bales 2009). Water primrose is found throughout the State in man-made impoundments, but is most problematic from the Fall Line to the coast. There are problem populations in Back River Reservoir, Goose Creek Reservoir, and the Santee Cooper lakes. Water primrose is an emergent perennial that grows to three feet tall, but its stems may be many feet long when floating on the water. This shoreline plant is very difficult to control due to extensive underground rhizomes. Unlike most shoreline species, new shoots can float on the water surface and extend far from shore. Adverse impacts include restricted public access to waterways and use of shoreline areas, impaired navigation in small channels, restricted water flow, formation of free-floating mats, and clogging of water intakes. Water primrose has been documented from one recreational fishing pond on the Forest (Bales 2009). Phragmites is more commonly found in freshwater impoundments along the coast and in estuaries and marsh ecosystems. It is not good waterfowl food and it outcompetes native plants that provide food and habitat for waterfowl (South Carolina Aquatic Invasive Species Management Plan 2008). Phragmites has been documented on the Forest (Robin Mackie, *personal communication*).

The Asian tiger mosquito now occurs statewide. This species is a competent vector of many viruses including dengue fever, Eastern equine encephalitis, potentially St. Louis and La Crosse encephalitis, as well as dog heartworm. The life cycle of this species is closely associated with human habitat and it breeds in containers of standing water. It is a very aggressive daytime biter with peaks generally occurring during early morning and late afternoon. It feeds on a number of hosts, including man, domestic, and wild animals. Its generalized feeding behavior contributes to its vector potential (South Carolina Aquatic Invasive Species Management Plan 2008).

The following table contains a list of aquatic nuisance species that either occur or may occur in the future on the Forest (South Carolina Aquatic Invasive Species Management Plan 2008).

The USDA Forest Service Southern Region Aquatic Nuisance Species Strategy, Aquatic Animals (Leftwich 2013) provides guidance for managing nuisance species and supports the South Carolina Aquatic Invasive Species Management Plan 2008. State agencies are recognized as the lead agency in controlling the establishment of aquatic nuisance species and managing established aquatic nuisance species both on and off the Forests.

Table 2-17. Occurrence of nuisance species on the Francis Marion National Forest

Aquatic Nuisance Species		Forest Occurrence	
Common Name	**Scientific Name**	**Present**	**Future Potential**
Fish			
Spotted bass	*Micropterus punctulatus*		x
Flathead catfish	*Pylodictis olivaris*	x	
Blue catfish	*Ictalurus furcatus*	x	
Green sunfish	*Lepomis cyanellus*		x
Northern snakehead	*Channa argus*		x
Asian swamp eel	*Monopterus albus*		x
Silver carp	*Hypopthalmichthys molitrix*		x
Bighead carp	*Hypophthalmichthys nobilis*		x
Black carp	*Mylopharyngodon piceus*		x
Grass carp (non-triploid)	*Ctenopharyngodon idella*		x
Animals			
Nutria	*Myocastor coypus*		x
Red-eared slider	*Trachemys scripta elegans*		x
Plants			
Hydrilla	*Hydrilla verticillata*		x
Water hyacinth	*Eichhornia crassipes*		x
Phragmites	*Phragmites australis*	x	
Water lettuce	*Pistia stratiodes*		x
Giant salvinia	*Salvinia molesta*		x
Alligatorweed	*Alternanthera philoxeroides*	x	
Brazilian elodea	*Egeria densa*		x
Water primrose	*Ludwigia uruguayensis*	x	
Insects			
Asian tiger mosquito	*Aedes albopictus*	x	
Asian mosquito	*Ochlerotatus japonicus*		x
Crustaceans			
Red swamp crayfish	*Procambarus (Scapulicambarus)clarkii*		x
Mollusks			
Viviparid snail	*Viviparus subpurpureus*		x
Viviparid snail	*Bellamya japonica*		x
Island applesnail	*Pomacea insularum*		x
Zebra mussel	*Dreissena polymorpha*		x
Asian clam	*Corbicula fluminea*	x	

Aquatic Nuisance Species and Climate Change. Increased temperatures, changes in rainfall and other environmental factors affected by climate shifts or change can create ideal conditions for proliferation of invasive plant and animal species, including parasites and pathogens. An increase in the number and diversity of native and non-indigenous invasive plant and animal species has been documented in South Carolina terrestrial, freshwater, and marine habitats. Some of these species may have been released accidently, but others are likely migrating northward from more tropical climates as a result of warming temperatures. Regardless of the manner in which they have become established, these species already are impacting native animals and their habitats. As climate changes, an increasing number of exotic species likely will migrate to South Carolina. Habitats can be destroyed as resources are over-utilized. Invasive and non-indigenous species have the potential to outcompete native species for food and other resources(http://www.dnr.sc.gov/pubs/CCINatResReport.pdf).

Tilapia is a warmwater, non-indigenous group of fish that extensively are stocked under permit in the State to control algae in private ponds. With few notable thermal refuges excluded, tilapia will die from cold stress in a typical South Carolina winter when water temperatures drop below 50 °F (10 °C). Historically, south coastal South Carolina water temperatures routinely drop to 45 to 50 °F (7 to 10 °C) during the winter. Tilapia could overwinter in the State if waters were to become warmer. Tilapia currently overwinters in Florida and has become an invasive species and a major management problem. If tilapia were to routinely overwinter in South Carolina it would result in direct competition with native and existing species for space, food, habitat and spawning areas, which could drastically alter natural fish communities. The destruction that non-indigenous peacock bass (*Cichla* spp.) can cause to native fish communities is well documented. In Florida, these fish currently are widespread, but are very temperature dependent and do not typically survive in waters cooler than 60 °F (16 °C). Given current South Carolina winter low temperatures, tilapia is much more of an eminent threat than peacock bass. However, if winter temperatures increase, peacock bass could become a threat in South Carolina. Other invasive fish that are common in Florida and could become established in South Carolina include various cichlids, pleco (*Hypostomus plecostomus*), Asian swamp eel (*Monopterus albus*), walking catfish (*Clarias batrachus*), various piranha and oscar (*Astronotus ocellatus*). All of these fish could, like tilapia, compete with native species for habitat, food and spawning resources (http://www.dnr.sc.gov/pubs/CCINatResReport.pdf).

The primary threats to lentic systems include sedimentation and water chemistry modification. Stresses include roads, drought, forestry management practices, and aquatic nuisance species. Road maintenance decreases vegetative growth in ditches where aquatic species forage and find refuge. Sediments are also added to the ditches with road grading activities. Impacts from forestry management practices are similar to those discussed for streams and rivers. Both plant and animal aquatic nuisance species can have huge impacts on contained pond systems where native species have no escape route. Drought conditions have been prevalent over the past decade on the Forest impacting pond water levels, water quality and populations.

2.1.2.8 Key Ecosystem Characteristics

Key ecological attributes for aquatic systems fall into these general categories: hydrological and energy regime, physical habitat structure, water quality and biota. These attributes constitute the critical components of aquatic system function. Any missing or altered characteristics would result in the loss of system function over time (Palmer et al. 2005). For this assessment, the key ecosystem characteristics are biological, physical (hydrological function, instream habitat, riparian areas) and chemical (water quality).

Biological

There are 73 species of fish that range in streams and rivers on the Forest. Some are entirely freshwater species, while others move between brackish and freshwater habitats and marine and freshwater habitats. There are an additional 37 marine, estuarine or anadromous fishes that have been recorded in tidal freshwaters of South Carolina (Rohde et al. 2009). There are five known crayfish species occurring on the Forest (Jones and Eversole 2011). All of these species occur in flowing waters as well as a variety of lentic habitats. Twenty-four mollusk species are known to occur within Forest waters, all but two recorded in streams or rivers (The Catena Group 2011). There is little known about aquatic insect populations on the Forest.

Fish inventory sampling in Francis Marion headwater streams was conducted in 1993 by Hansbarger and Dean (1994). A total of 53 stream sites was sampled across the Forest post Hurricane Hugo, yielding 35 fish species. Stream monitoring efforts in some of these same streams were conducted for fiveyears between 2002 and 2010. Repetitive sampling in streams varied from year to year due to drought conditions or above average rainfall. Dry stream channels were encountered with drought and below average rainfall. Stream channels were indiscernible with the swampy conditions produced by above average rainfall during one sampling year. Thirty-five of the original stream sites have been resurveyed, along with the two additional headwater streams, yielding 37 fish species. Nine species captured in 1993 were not present in later sampling years. Nine different species captured in later sampling years were not present in the 1993 sampled streams. Fish abundance recorded in 2010 was noticeably less than in previous inventory years, most likely due to drought conditions (Krause and Roghair 2010). The number of species captured by watershed is displayed in Table 2-18.

Table 2-18. Table number of fish species captured per Forest watershed

	Number of Species Captured					
Watershed	**1993**	**2002**	**2003**	**2004**	**2006**	**2010**
Awendaw Creek	12	14	NS[1]	NS	8	5
Wando River	4	NS	4	6	12	7
Quinby Creek	11	4	10	NS	9	6
Huger Creek	12	1	4	NS	8	10
Wadboo Creek	17	NS	4	NS	7	12
Wedboo Creek	13	14	8	NS	14	8
Dutart Creek	3	NS	2	NS	8	0
Echaw Creek	19	4	13	NS	11	12
Red Bluff Creek	7	NS	9	NS	8	7
Wambaw Creek	14	10	8	NS	19	12

[1] NS = Not sampled.

Existing population conditions and trends are unknown for crayfish and mollusk. Crayfish and mollusk surveys were conducted across all Forest watersheds in 2011. A total of 84 streams were sampled for crayfish. Crayfish were collected in 72 of these streams. A total of 38 streams were sampled for mollusk species. Mollusk species were found in 26 streams. Thirteen mussel species, three clam species and eight snail species were collected in 2011.

The Catena Group report (2011) concluded that mussel diversity was low within stream reaches on the

Forest, which is considered typical of tannic, swamp water streams along the Atlantic Slope. However, a few streams characterized as having wide, natural riparian buffers contained very high densities of mussels.

There are 62 species of fish that range in lentic systems on the Forest, including those systems nested within the various terrestrial ecosystems (see section 2.1.1 "Terrestrial Ecosystems"). Some are entirely freshwater species, while others also occur in brackish and marine habitats (Rohde et al. 2009). There are five known crayfish species occurring on the Forest (Jones and Eversole 2011). All of these species occur in a variety of lentic habitats as well as flowing waters. One burrowing species is found in wet powerline corridors. Eleven mollusk species have been recorded in lentic systems (The Catena Group 2011).

The primary game fish managed in recreational fishing ponds include largemouth bass, bluegill and redear sunfish. Catfish are occasionally stocked in some ponds for public fishing events. Sterile grass carp have been stocked in the past to control aquatic vegetation. Water quality and fish populations were monitored in November 2009 (Bales 2009). Aquatic plants were identified as well as the percent coverage of plants on the pond. The populations in the majority of ponds were out of balance, crowded with underweight bass. Bluegill have since been stocked at recommended rates. Twelve of the ponds had low alkalinity and needed to be limed for aquatic species productivity.

Physical

The hydrological condition of Forest streams has been discussed in this section under connectivity of habitat in relation to dams, roads, and trails. Density of these structures across the Forest indicate that all Forest watersheds will be ranked as highly modified by these physical structures. Aquatic organism passage will be assessed in the future for road crossings when funding becomes available. In addition, more information on hydrological function and characteristics is discussed in section 2.1.3 "Watersheds," section 2.2.3 "Water Resources and Quality", and section 2.2.5 "Riparian Areas, Wetlands and Waters."

Riparian areas are integral to aquatic ecosystems in that they maintain certain functions essential to healthy streams and species diversity. Riparian areas influence temperature, habitat diversity, channel morphology, productivity and species diversity. Water temperature is sustained by riparian canopy cover. Riparian areas also function as filters to water bodies from sediments and other pollutants. Riparian areas and associated floodplains are inhabited by some crayfish species as well as a number of wildlife species. The hardwood component of the riparian provides readily available food sources to the macroinvertebrate community through leaf litter and detritus. Canopy component diversity is important because the leaves of different tree species break down at various rates and are used by macroinvertebrates for food and shelter. Instream habitat diversity is dependent on large wood input from the riparian area. Larger wood is more stable and most likely to create and maintain habitat diversity in a stream. Therefore canopy age becomes an important factor for instream habitat. Replacement of the hardwood component in riparian areas impacts instream wood recruitment and longevity. Hardwood tends to decay slower than pine species in the stream environment and pine needles are not as desirable a food source as hardwood leaves. Wood is also used as cover from predators and can provide drought refuge when deeper pool habitat is created. In a recent inventory of prescribed burning effects on large wood loading on the Forest, data revealed that in over 20 kilometers of headwater stream sections, the largest, most stable wood was deficient (USDA FS SRS Center for Aquatic Technology Transfer, Draft). Fire in riparian areas has been discussed in this section under threats and stresses. Loss of riparian vegetation and instream large wood from burning

may have an impact on aquatic systems. Riparian extent on the Forest has been mapped using soil indicators and 29 acre catchment areas, due to the lack of an accurate stream layer map. Present unmanaged riparian extent is small (approximately 30 feet) on headwater streams and somewhat larger on streams with more floodplain area. In addition, mechanical construction and reconstruction of fire lines through riparian areas and across streams may be a source of stream sediment, may produce passage barriers and may crush aquatic species without the ability to move from the area. More information on riparian function and characteristics is discussed in section 2.2.5 "Riparian Areas, Wetlands and Waters".

Riparian areas are important to lentic systems in the same manner discussed above for streams.

Chemical

Aquatic species usually have a tolerance range for certain water quality parameters such as temperature, dissolved oxygen, pH and alkalinity. These parameters may be impacted by human activities (riparian disturbance and pollutants) and natural disturbances (drought and flooding). Fecal coliform and methyl mercury are a problem in coastal streams and are discussed more in section 2.1.3 "Watersheds." Tributary streams in the lower Santee River may be experiencing an increase in salinity due to the dam and diversion canal modifications of the river system. With less freshwater river flow, tidal waters move further up river and into tributaries such as Wambaw Creek. This can restrict the amount of freshwater habitat available in these streams.

Where lentic systems are not associated with floodplains, they are completely dependent upon rainfall to maintain physical and chemical integrity.

Climate Change

Impacts to native aquatic species from nuisance species increase due to climate change is discussed in this section under "Threats and Stresses."

Climate change and increasing climate variability will contribute to changes in water quantity and water quality in the southern United States. Changes in seasonal precipitation on the Forest showed a slight upward trend in falls and winters over the last six decades and a downward trend in springs and summers. Therefore climate warming potentially may bring more spring and summer droughts to the area. This could have a great impact on aquatic ecosystems during summer drought periods when there are high evapotranspiration demands. Freshwater aquatic systems are susceptible to changes in precipitation. Streams, rivers, lakes and ponds are dependent upon both precipitation and groundwater recharge to maintain flow and water levels. Changes in surface and groundwater levels can affect the species assemblages and migration in freshwaters throughout the State (www.dnr.sc.gov/pubs/CCINatResReport.pdf). As climate changes, further habitat fragmentation will restrict movement of animals, limiting or preventing the critical ability to migrate to more favorable habitats.

Changes in the location of the saltwater/freshwater interface will affect many freshwater and diadromous fish species. As sea level rises, saltwater will move further up the river systems of the State. Species with low salt tolerances and diadromous fish will be limited in their ability to move upstream into better quality habitat due to dams and hydroelectric reservoirs constructed on most South Carolina riverine systems. The amount and distribution of aquatic vegetation also will change in response to increases in salinity, limiting cover and food sources for aquatic organisms. Additionally, the potential exists for increased demand for water releases from reservoirs to fight the salt wedge that will be moving inland (www.dnr.sc.gov/pubs/CCINatResReport.pdf).

Management options suggested for aquatic ecosystems in the face of climate change include the following from Adams (http://www.fs.fed.us/ccrc/topics/aquatic-ecosystems/warmwater-aquatic-fauna.shtml#f-tabs-5).

- Maintain natural hydrograph.
- Maintain groundwater levels and identify and conserve critical groundwater-dependent ecosystems.
- Protect and restore habitat and water quality.
- Maintain or restore habitat connectivity.
- Manage for robust and redundant populations.
- Reevaluate fisheries management strategies.
- Unite planning for conservation and human water supply.

2.1.2.9 Natural Range of Variability

The reference condition for watershed, hydrological, and aquatic conditions is pre-Columbian, before nonnative human influences that began about 500 years ago. This period fell within the Little Ice Age, when weather conditions were more humid and colder from about 150 to 650 years ago. There were colder or warmer weather cycles during the period, but the effects to North America were less. Sea levels were approximately two feet lower. Beaver were abundant but trapped out by the 1700s, making it initially locally wetter. This period is before roads, dams, dikes, railroads, drainage ditches, stream channelization, rural and urban development, air pollution from burning coal, etc. Since most post-Columbian anthropogenic hydrologic modifications directly or indirectly helped drain or control flooding and tidal influence of the land, the conditions would have likely been less runoff, more flooding, greater hydroperiods, higher evaporation, increased hydration of floodplains, and probably increased stream permanence. There were localized to extensive riparian bottomland and wetland forests of varying sizes and types, and some increases in their extent would be reasonable to assume. Primary disturbance regimes included intensity, frequency and disturbance from fire, flooding, and severe wind. Other natural surface and hydrologic disturbance included beaver, deer, elk as well as some local buffalo presence. Due to the low gradient characteristic of most of the topography, sinuous stream types dominated. The low gradients with vegetation and rooting density provided resilient and highly stable stream channels.

2.1.2.10 Information Needs

- Road culvert inventory and stream layer map.
- GIS information by watershed based on a stream layer map: riparian acres; stream miles broken into perennial, intermittent and ephemeral; road and trail density; road and trail density in riparian area.
- Aquatic organism passage survey and mapping.
- Instream habitat surveys.

2.1.3 Watersheds

2.1.3.1 Preliminary Findings

►The U.S. Geologic Survey and USDA Natural Resources Conservation Service in cooperation with other agencies have classified the hydrologic units (HUCs) across South Carolina (Eidson et al. 2005). The categories classified, each with a two digit code, were region, subregion, basin, subbasin, watershed, and subwatershed. Figure 2-5 has the 8-digit subbasin codes and the 4-digit watershed and subwatershed codes included for the Forest vicinity. The subbasins associated with the Francis Marion flow to Cooper River, Santee River and Atlantic Ocean coast (including the Atlantic Intercoastal Waterway). The hydrologic boundaries were extended into the ocean based on bathymetric indicators. The Francis Marion National Forest proclamation boundary and ownership are included in Figure 2-5.

►Nationwide efforts for the assessment and improvement of watershed condition were developed in 2011. The application of this direction continues to be refined as implemented. This is another step to further recognize the importance of water to not only national forest resources, but also the needs for the economic and public benefit of water in development and growth. It provides a rating system to compare watershed condition and be able to track them over time as watershed improvements are made. Consistent with new national direction, additional procedures to assess watershed condition began in 2011 by an integrated approach by the Forest personnel. The Forest analysis of the watershed condition of the Francis Marion subwatersheds classified them to be in class 2, fair condition for watersheds which exhibit moderate geomorphic, hydrologic, and biotic integrity relative to their natural potential condition (USDA Forest Service 2011c). The 12-digit subwatershed codes with names and the ratings of watershed condition indicators and attributes are included on Watershed Condition Summary **Error! Reference source not found.**. However, the 2011 Forest analysis of the watershed condition did not have the LiDAR and recent information obtained.

►The current assessment of watershed conditions has the potential to be refined and improved based on information being found with LiDAR and other analyses (USDA Forest Service 2011c; Hansen et al. 2013). Although the presence of hydrologic, channel geomorphic and riparian modifications were generally known in 1985 and 1996, the frequency and extent of these modifications were not. The average watershed has about 100 potential modifications to stream channels from road crossings and dikes, not counting ditching and channel straightening. With this knowledge, ratings of various watershed condition indicators and attributes may change upon reevaluation.

►Hydrologic boundaries and stream extent and location in former plans were based on the 10-foot USGS topographic contour maps. Due to the relatively flat terrain and dense vegetation, there was a substantial amount of uncertainty associated with estimating their location (Eidson et al. 2005; Amatya et al. 2008, 2011, 2013). Improvements in the boundary and stream coverages are needed to reflect the LiDAR and other associated available information. The U.S. Geological Survey has been contacted and willing to test/apply Forest Service information as perhaps an example or a pilot for other coastal areas. These changes are needed for Forest as well as project planning.

►Watersheds were not evaluated in 1985 or 1996 relative to their condition. In the watershed condition ratings (USDA Forest Service 2011c), all subwatersheds rated in fair condition in about the middle of the fair rating category between 1.7 and 2.2. The primary individual attributes that averaged poor conditions across the Forest were the water quality impairment or

problems from primarily methyl mercury and/or fecal coliform, aquatic habitat fragmentation, lack of large woody debris, and road density and maintenance. The extent of hydrologic modifications may have influenced attributes such as channel form and riparian function. As a result, there is some uncertainty about the ratings. The Forest plan is an appropriate place to address watershed conditions and apply integrated watershed planning as a tool to address a variety of resources and issues.

2.1.3.2 Direction in the 1996 Francis Marion Forest Plan

The former Forest land and resource management plans did not directly address watershed condition (USDA Forest Service 1985, 1996a, 1996b). Watershed planning was an available option, and the Forest analysis did have access to basin and subbasin assessments conducted by the State. Approximate watershed and subwatershed divisions were present for both plans. However, there have always been uncertainty with boundary and stream location (Eidson et al. 2005; Amatya et al. 2011, 2013).

Available information on coastal watersheds has been limited, and that was why the Santee Experimental Forest Hydrometerological Studies were elevated nationally as the coastal ecohydrologic research area. At the time of the 1985 and 1996 plans, there had been only limited emphasis to consider analyzing by watershed, and the preference was to use ecological landtypes in 1996.

During these plans, the standard topographic information was the USGS topographic maps which used 10-foot contours and identified only the primary streams and wetland areas. One must consider that details such as the smaller stream locations were hidden under a heavy canopy, midstory trees, and other vegetation. Drainage boundaries were also uncertain in the relatively flat terrain. The primary hydrologic divisions addressed for the 1996 plan were at the basin or subbasin scale that divided areas draining to the Santee River, Cooper River, and Atlantic Coast. Information on 5th- and 6th-level watersheds was seldom used unless as a descriptive tool, and these smaller hydrologic units were more of a project-level tool, rather than a Forest-level planning tool. However, fish species sampling in 1993 and 1994 with Dr. John Dean (University of South Carolina) considered watershed and subwatershed boundaries, geology, soil, channel types and other information in stratifying the Forest to better sample and document these differences in condition with respect to fish. Most current activities use the subwatershed or watershed boundaries to define analysis areas for environmental assessment. Analysis is also done relative to ecological boundaries.

Since the 1996 plan, a substantial amount of data and experience has been gained in analyzing by hydrologic units of various sizes. In addition, recent developments in applying LiDAR, flow accumulation models, GIS and other tools have made a big difference in estimating hydrologic boundaries, stream, wetland, and riparian locations, and increasing assessment and analysis capability and capacity (Hansen et al. 2013). Most planning analysis in 1985 and 1996 was done by dividing the land into compartments and stands, the local timber management units. These units are still included.

In 1996, the Francis Marion was also divided in the major ecological management units including sandy ridges and sideslopes; loamy ridges, flats and river/creek bottoms; flatwoods and loamy ridges; and swamps and swampy flats. Other management areas concentrated on special areas, wilderness, the Santee Experiment Station and research natural areas. The red-cockaded woodpecker recovery plan was highly important and integrated throughout the plan. Riparian areas and wetlands were primarily protected by standards and best management

practices, but mostly managed as suitable for timber production with limited roads and other major activities. However, the South Carolina Forestry Best Management Practices were mandatory on the Forest and included as direction in both 1985 and 1996 plans (South Carolina Forestry Commission 1976, 1994, 2000).

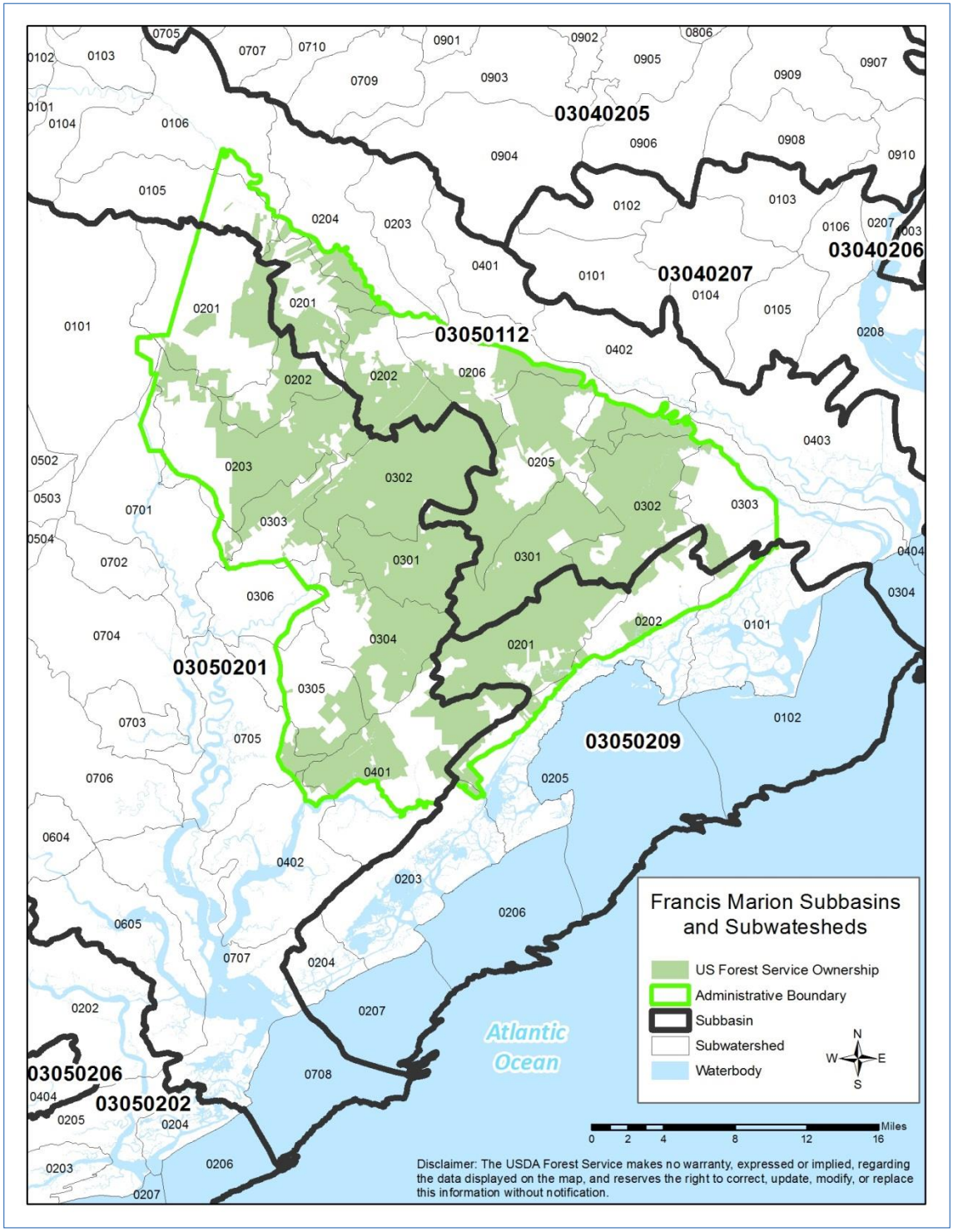


Figure 2-5. Francis Marion National Forest subbasin and subwatershed boundaries

2.1.3.3 New Policy or Direction Since 1996

Since the 1996 plan, a substantial number of forests have developed more demanding and inclusive prescriptions to address watershed conditions addressing riparian areas, wetlands and aquatic ecosystems in more detail (Holcomb 1999). Nationwide efforts for the development of best management practices and watershed condition assessment and improvements were developed and implementation has begun. Many of these efforts have gone further to recognize the importance of watersheds and water to not only national forest resources, but also the needs for the economic and public benefit of water in development and growth (USDA Forest Service 2011a, 2011b).

In 2011, all national forests began a process to evaluate and begin to address watershed condition within the national forests using the newly developed protocols (USDA Forest Service 2011a, 2011b). The Forest interdisciplinary resource team used existing information and national guidance to evaluate watershed condition indicators and attributes to help rate the watershed conditions for the 22 Francis Marion subwatersheds (6th-level hydrologic unit code [HUC]) with over 5 percent National Forest ownership. The results of this analysis for the 16 subwatersheds with 24 percent or more National Forest ownership are presented in **Error! Reference source not found.** and Figure 2-7 (USFS 2011c).

At this time, no subwatersheds on the Francis Marion have been identified by the Forest leadership to receive priority improvement. Needs on the Sumter National Forest have initially been a higher priority in South Carolina. However, the intent is for at least one priority watershed that needs improvement to be identified on each ranger district. The subwatersheds on the Francis Marion identified in 2012 for potential consideration for improvement were Turkey Creek of East Fork Cooper River and Headwaters of Wambaw Creek, tributary to the Santee River.

Turkey Creek was recommended as a potential priority subwatershed because of additional funding opportunity with approximately 20 timber sales tied to the Hellhole and Honey Hill EAs, probably the most available information with ongoing hydrological and ecological research, and portions are inside the core burning area with associated proposed, endangered, threatened, and sensitive species including red-cockaded woodpecker.

Headwaters of Wambaw Creek was recommended due to its presence in wilderness with intermittent dam effects from salt water entry, ongoing small craft motorized boating, substantial soil and water restoration potential given the amount of land and stream alteration, portions are contained within core burn area, abundant unique proposed, endangered, threatened, and sensitive species, and threat from wild hogs.

Within the watershed condition framework and analysis, a variety of issues were identified in interdisciplinary analysis in the effort to help estimate and rate watershed conditions using the national protocol. The system used a numerical rating system based on poor to good categories for a number of watershed indicators and associated attributes that contribute to the rating of these indicators. The ratings of the indicators were weighted on watershed importance, and are compiled numerically into an overall watershed score, that can fall into one of three categories. Good watershed condition with a score between 1.0 to 1.6 is considered properly functioning, as these watersheds exhibit high geomorphic, hydrologic, and biotic integrity relative to their natural potential condition (USDA Forest Service 2011a). Fair watershed condition with a score of 1.7 to 2.2 is declining or functioning at risk, and these watersheds exhibit moderate geomorphic, hydrologic, and biotic integrity relative to their natural potential condition. Poor watershed conditions with scores of 2.3 to 3.0 are not functional, with watersheds that exhibit low geomorphic, hydrologic, and biotic integrity relative to their natural potential condition. There are a variety of resource issues that were compiled within the watershed condition analysis, and readily available information and knowledge was used (USDA Forest Service 2011c). The Forest evaluation of watershed condition was primarily internal, using existing information with limited public

involvement in this process. However, future watershed condition evaluations will be more collaborative with public input and involvement. The plan has increased level of public involvement and collaboration, so added awareness, attention and review of watershed condition and evaluation is intended. Efforts should take advantage of key agency contacts, partnerships or other agreements, awareness education and technology transfer of watershed conditions, including discussion of techniques used, identifying resource areas needing improvement and opportunities to improve them.

The ratings of watershed attributes and indicators for the 16 subwatersheds with 24 percent or more ownership on the Francis Marion are summarized in **Error! Reference source not found.** and Figure 2-7. The ratings varied from 1.7 to 2.0, which is considered class 2 or fair watershed conditions. The primary individual attributes that averaged poor conditions across the Forest were the water quality impairment or problems attributes from methyl mercury, fecal coliform, aquatic habitat from fragmentation, lack of large woody debris and road maintenance. Road density was contributory for some. The analysis of watershed issues lacked detail associated with indicators of excessive sediment and channel form, which the assessment and plan analysis will address in more detail. The extent of hydrologic modifications and how these may have influenced indicators and attributes was not fully realized in 2011 Watershed Condition Analysis. It is likely that a few of these attributes are in poorer condition than realized. Besides affecting aquatic, wetland, and riparian habitat, the hydrologic modifications may have influenced the transport of fecal coliform, methyl mercury, or other pollutants to downstream areas. In some instances, the hydrologic modifications were used to limit the extent of tidal influence, and several subwatersheds have been affected by salinity increases due to much lower than natural flows in the Santee River that allows for tidal effects to a historically freshwater system. In other instances, the modifications were also used to retain water for rice culture management, reduce flooding, drain wetlands, or increase water-based access to fresh and tidal waters.

Watershed condition and health also includes other factors such as fire condition class, insects and disease (forest health), invasive species, and spread and riparian/wetland vegetation. For the Francis Marion subwatersheds (6th-level HUCs), these factors generally rated fair. However, LiDAR detail that has been used to detect and highlight about 100 hydrologic modifications per subwatershed could be linked to aquatic fragmentation, riparian health and channel form was not available at that time of initial watershed condition assessment. Refinement of surface features including watershed boundaries, stream locations and extent, soil boundaries, wetlands, riparian areas, ecological classification and tidal influence are expected. These refinements continue to be developed and realized.

There will be ongoing efforts to improve information available for Forest plan analysis and get it incorporated into official data bases such as the National Hydrology Database or Watershed Boundary Database. Contacts have been with the U.S. Geological Survey made to formalize these data base improvements as they are critical to many of the analyses that will be conducted. Improvements in ecological classification based on Nature Serve Classification (Pyne and Nordman 2012) and refined delineation (Simon and Heyden 2013) are expected to improve analysis capability. There could be other inventory updates, information improvements, or improved understanding that may influence the integrated analysis and rating of watershed conditions.

However, the hydrologic modifications have been so extensive on the landscape, resulting from roads, trails, trams, farming, forestry, development, and water management structures or activities (including dams, dikes, canals, stream relocation and straightening), and have potential to modify watershed condition and function in ways that were not considered. Draining wetlands for farming or to improve sites for pine management were once common practices, encouraged and/or supported by the State and others (South Carolina Regulations, Title 49, 1911, 1920 to 1962, Berkeley County et al. 1963). Early farming crops included rice plantations which often used dikes to manage the extent and amount of fresh

water. As mentioned, some structures were used to limit tidal influence or contain freshwater for flushing freshwater during especially high or wind driven tides.

The entry of salt water up the Santee River system after the development of the Santee Cooper Project was one of the various reasons for abandonment of the rice culture plantations along the lower Santee River according to Will Doar, South Carolina Geologist (2013). Some of these former rice culture areas were modified for wildlife habitat improvements which may have enhanced local recreational uses as hunting, fishing and/or bird watching. In all probably, without some continuing maintenance, many of these structures may have failure points, but still be partially effective at altering conditions. Other modifications may have improved commercial or recreational navigation access to tidal or non-tidal waters. Evaluations considering these items were limited in past Forest plans as well as watershed condition assessment.

Watershed condition changes are being influenced by a number of factors that the plan assessment has found that were probably not evaluated. Other factors of consideration include but are not limited to the following:

1. The area population growth and expansion has implications.
2. Increase in intensity of forest thinning and management for forest health after Hurricane Hugo.
3. Increase in use of fire and other tools to manage fuel hazards in the wildland-urban interface and address associated habitat needs.
4. Beaver are naturally returning in some stream systems.
5. Wild hogs have been a historic issue that causes watershed damage.
6. Sea-level rise induced by climate change.
7. Pressures associated with population increase and localized urbanization.

Many of these same issues are also present on private lands, but were not specifically assessed in the Forest-level watershed condition analysis. The relative effects on private lands were estimated based on indicators from Brown and Froemke (2010). Their work addressed a variety of stressors that were not specifically addressed in the Watershed Condition Framework, but are indicators of relative differences in other stressors and a reference for comparison. Some of their stressors, such as population in the watershed, may have implications to consider for this assessment. The Brown and Froemke approach was used to rate and compare expected management and conditions on both National Forest and private lands for each watershed across the Nation. The overall watershed condition considered if the Brown and Froemke rating of private lands were better, about the same, or in a poorer condition in comparison to the national forest lands. In most instances, the private lands within the watersheds rated the same as the national forest lands. Guerin Creek (Wando River) within the East Fork of the Cooper River was the only one with showed a poorer condition using this rating system, and this may have been due to the population growth and urbanizing development in this area. However, the data used in their assessment may be dated, so it may not account for some recent growth experienced in the urban interface.

The watershed condition assessment is a tool to use to identify, address, and integrate a variety of resource areas that influence watershed health issues. There is national direction to not only use this tool, but track watershed condition improvements over time. The existing Watershed Condition Action Plans on the Sumter National Forest in South Carolina have tended to concentrate on and address the indicators or attributes in the poor category, resulting in improvements primarily in the areas of water quality (erosion and sediment reduction), aquatic habitat (large wood), prescribed burning, thinning, road maintenance, road closure, and treatment of nonnative invasive species. Factors that are currently in fair

or good conditions are to be maintained or improved as appropriate to be consistent with other resource needs. A similar integrated approach at addressing problem areas for project-level work will probably be used for any priority watersheds identified on the Francis Marion National Forest.

shows summary data from watershed condition assessment, developed by the Forest interdisciplinary team in 2011.

Figure 2-7 shows summary data from watershed condition assessment, developed by the Forest interdisciplinary team in 2011. Table is color coded relative to watershed outlet is the Cooper River, then Atlantic Ocean. Attribute values of 1=good, 2=fair, and 3=poor. Indicators are the average of their attributes, watershed score a weighted average of all the indicators. See also Watershed Condition Framework and Implementation Guidance documents (USDA Forest Service 2011). Several smaller subwatersheds with less than 24 percent Forest Service ownership were removed for easier viewing. More detail is available in the process record.

HUC12_Code	030501120201	030501120202	030501120205	030501120206	030501120301	030501120302	030502090201
Subwatershed, HUC 12 Name	Wedboo Creek	Savanna Creek	Echaw Creek	Dutart Creek-Santee River	Headwaters Wambaw Creek	Outlet Wambaw Creek	Awendaw Creek
Watershed_Score_FS_Avg	1.8	1.7	1.9	1.9	1.8	1.9	1.9
Total Watershed_Score	1.8	1.7	1.9	1.9	1.8	1.9	1.9
Total_Watershed_Area_Acres	15499	17246	28411	29210	21530	24588	25686
FS_Area_Acres	8419	12888	19761	10781	20434	21332	22010
FS_Area_Percent	54	75	70	37	95	87	86
1 Indicator_Aq_Phys_Water_Qual	2	2	3	3	2	3	3
1.1 Attribute_Impaired_Waters	1	1	3	3	1	3	3
1.2 Attribute_Water_Qual_Probs	3	3	3	3	3	3	3
2 Indicator_Aq_Phys_Water_Qnty	2	2	3	2	2	3	2
2.1 Attribute_Flow_Characteristics	2	2	3	2	2	3	2
3 Indicator_Aq_Phys_Habitat	2	2	2.3	2.3	2.3	2.3	2.3
3.1 Attribute_Hab_Fragmentation	2	2	2	2	2	2	2
3.2 Attribute_Large_Woody_Debris	2	2	3	3	3	3	3
3.3 Attribute_Channel_Shape_Func	2	2	2	2	2	2	2
4 Indicator_Aq_Bio_Biota	1.3	1.3	1.3	1.3	1.3	1.3	1.3
4.1 Attribute_Life_Form_Presence	1	1	1	1	1	1	1
4.2 Attribute_Native_Species	1	1	1	1	1	1	1
4.3 Attribute_Aq_Invas_Species	2	2	2	2	2	2	2
5 Indicator_Aq_Bio_Rip_Veg	2	2	1	2	2	1	2
5.1 Attribute_Riparian_Veg_Cond	2	2	1	2	2	1	2
6 Indicator_Terr_Phys_Road_Trail	2	1.8	2	1.8	1.8	2	2
6.1 Attribute_Open_Road_Density	3	2	2	2	2	2	2
6.2 Attribute_Road_Maintenance	3	3	3	3	3	3	3
6.3 Attribute_Proximity_Water	1	1	2	1	1	2	2
6.4 Attribute_Mass_Wasting	1	1	1	1	1	1	1
7 Indicator_Terr_Phys_Soils	1.3	1.3	1.3	1.3	1.7	1.7	1.7
7.1 Attribute_Soil_Productivity	2	1	1	1	2	2	2
7.2 Attribute_Soil_Erosion	1	1	1	1	1	1	1
7.3 Attribute_Soil_Contamination	1	2	2	2	2	2	2
8 Indicator_Terr_Bio_Fire	3	2	1	2	2	1	2
8.1 Attribute_Fire_Cond_Class	3	2	1	2	2	1	2
9 Indicator_Terr_Bio_ForCover	1	1	1	1	1	1	1
9.1 Attribute_Forest_Cover	1	1	1	1	1	1	1
10 Indicator_Terr_Bio_Range	na	na	na	na	na	na	na
10.1 Attribute_Range_Veg_Condtion	na	na	na	na	na	na	na
11 Indicator_Terr_Bio_Invasive	1	1	2	2	1	1	1
11.1 Attribute_Extent_SpreadRate	1	1	2	2	1	1	1
12 Indicator_Terr_Bio_ForHealth	2	1.5	1.5	1.5	1	1	1.5
12.1 Attribute_Insects_Disease	3	2	2	2	1	1	2
12.2 Attribute_Ozone	1	1	1	1	1	1	1
Special designations			Intermittent tidal	Short nose sturgeon, Atlantic sturgeon, manatee	Wambaw Swamp Wilderness	Wambaw Creek Wilderness, intermittent tidal	Coastal Shellfish, tidal, boating, Little Wambaw Swamp Wilderness
Flows to Santee River, then Ocean							
Flows to Ocean							

Figure 2-6. Francis Marion National Forest, summary data from watershed condition assessment

HUC12_Code	30502010201	030502010202	030502010203	030502010301	030502010302	030502010303	030502010304	030502010305	030502010401
Subwatershed, HUC 12 Name	Walker Swamp	Cane Pond Branch	Wadboo Creek	Turkey Creek-East Branch Cooper River	Nicholson Creek	Gough Creek	Quinby Creek	French Quarter Creek	Guerin Creek (Wando River)
Watershed_Score_FS_Avg	2	1.8	2	1.8	1.9	1.8	1.9	1.8	2
Total Watershed_Score	2	1.8	2	1.8	1.9	1.8	1.9	1.8	2.6
Total_Watershed_Area_Acres	37202	10755	34431	16516	29253	12460	22693	19354	40024
FS_Area_Acres	8912	7572	20965	16153	28501	6429	14081	4968	16819
FS_Area_Percent	24	70	61	98	97	52	62	26	42
1 Indicator_Aq_Phys_Water_Qual	3	2	3	3	2.5	2	2	2	3
1.1 Attribute_Impaired_Waters	3	1	3	3	2	1	1	1	3
1.2 Attribute_Water_Qual_Probs	3	3	3	3	3	3	3	3	3
2 Indicator_Aq_Phys_Water_Qnty	2	2	2	2	2	2	2	2	2
2.1 Attribute_Flow_Characteristics	2	2	2	2	2	2	2	2	2
3 Indicator_Aq_Phys_Habitat	2.3	2	2.7	2.3	2.3	2.7	2.7	2.3	2.3
3.1 Attribute_Hab_Fragmentation	3	2	3	2	2	3	3	2	2
3.2 Attribute_Large_Woody_Debris	2	2	3	3	3	3	3	3	3
3.3 Attribute_Channel_Shape_Func	2	2	2	2	2	2	2	2	2
4 Indicator_Aq_Bio_Biota	1.7	1.3	1.7	1.3	1.3	1.7	1.7	1.3	1.3
4.1 Attribute_Life_Form_Presence	1	1	1	1	1	1	1	1	1
4.2 Attribute_Native_Species	2	1	2	1	1	2	2	1	1
4.3 Attribute_Aq_Invas_Species	2	2	2	2	2	2	2	2	2
5 Indicator_Aq_Bio_Rip_Veg	2	2	2	1	2	1	2	2	2
5.1 Attribute_Riparian_Veg_Cond	2	2	2	1	2	1	2	2	2
6 Indicator_Terr_Phys_Road_Trail	2.3	2.3	2.3	2	2	2.3	2.3	2.3	2
6.1 Attribute_Open_Road_Density	3	3	3	2	2	3	3	3	2
6.2 Attribute_Road_Maintenance	3	3	3	3	3	3	3	3	3
6.3 Attribute_Proximity_Water	2	2	2	2	2	2	2	2	2
6.4 Attribute_Mass_Wasting	1	1	1	1	1	1	1	1	1
7 Indicator_Terr_Phys_Soils	1.3	1.3	1.3	1.7	1.7	1.3	1.3	1.3	2
7.1 Attribute_Soil_Productivity	1	1	1	2	2	1	1	1	3
7.2 Attribute_Soil_Erosion	1	1	1	1	1	1	1	1	1
7.3 Attribute_Soil_Contamination	2	2	2	2	2	2	2	2	2
8 Indicator_Terr_Bio_Fire	3	3	2	1	2	2	2	3	3
8.1 Attribute_Fire_Cond_Class	3	3	2	1	2	2	2	3	3
9 Indicator_Terr_Bio_ForCover	1	1	1	1	1	1	1	1	1
9.1 Attribute_Forest_Cover	1	1	1	1	1	1	1	1	1
10 Indicator_Terr_Bio_Range									
10.1 Attribute_Range_Veg_Condtion									
11 Indicator_Terr_Bio_Invasive	1	1	1	1	1	1	1	1	1
11.1 Attribute_Extent_SpreadRate	1	1	1	1	1	1	1	1	1
12 Indicator_Terr_Bio_ForHealth	2	2	1.5	1.5	1.5	1	1.5	1.5	1.5
12.1 Attribute_Insects_Disease	3	3	2	2	2	1	2	2	2
12.2 Attribute_Ozone	1	1	1	1	1	1	1	1	1
Special designations				Experimental watersheds, Research	Hellhole Bay Wilderness, Experimental watersheds, Research				Some tidal influence
Flows to Cooper River, Ocean									

Figure 2-7. Francis Marion National Forest, summary data from watershed condition assessment

2.1.3.4 Stressors or Threats

There are a variety of stressors and threats that exist or could materialize to influence watershed condition. Many of them are addressed within the watershed condition framework and analysis, or have been mentioned. Most will be directly or indirectly addressed in other sections with national forest land and resource planning and management documents. Stress or threats include population growth and urban expansion, climate change, hurricanes, floods, droughts, wildfire, insects and disease, nonnative invasive species, roads, motorized trails, a variety of land use based ground-disturbing activities, atmospheric deposition (e.g., mercury), fecal pollutants, and hydrologic modifications. Some of the watersheds are being affected by sea-level rise and tidal changes. The degree to which watersheds are stressed or threatened vary. Most watersheds have been substantially modified in comparison to what one would expect of a national forest, yet their resiliency promotes the production of many goods, services, and public benefits. The low gradient and rapid vegetation response help in their recovery after disturbance, and it is relatively easy to think that all things are well. But the variety of hydrologic modifications from dams, dikes, canals, dredged channels, ditches, site bedding, severe ruts, road crossings, trams, frequent as well as lack of fire, and firelines are complex to understand and evaluate. It would take a close integrated look, but the desired conditions spoken to in the 1996 plan for resilient, properly functioning aquatic, riparian and wetland systems has not been fully realized or addressed. Much of this awareness of these shortcomings is based on recent information and analysis, and failing to act on these issues was not intentional.

2.2 Air, Soil, and Water Resources and Quality

2.2.1 Air

2.2.1.1 Preliminary Findings

►Air pollution emissions of sulfur dioxide, nitrogen oxides, ammonia, fine particulate matter, and mercury have the greatest potential to impact the natural resources and the services they provide on the Francis Marion National Forest.

►Annual emissions of sulfur dioxide and nitrogen oxides had large deceases between 2002 and 2008. Emissions of fine particulate matter from Forest Service prescribed fires probably increased between 2006 and 2011 as well as other source in the region.

►None of the National Ambient Air Quality Standards (NAAQS) are exceeded within or near the National Forest.

►There has been a significant decline in fine particulate matter concentrations between 2004 and 2010 for both the daily and annual NAAQS, even with an increase in the number of acres treated with prescribed fires on the Francis Marion National Forest.

►Regional air quality planners have utilized information provided by the Forest Service on the location, timing, size, and amount of fuel consumed for 2002, as well as forecasts for 2018, for NAAQS and Regional Haze planning. The 50,569 acres treated with prescribed fires in 2010 did exceed the 2018 forecast of 45,000 acres, but the NAAQS was attained at the closest ambient monitors and reasonable progress in visibility conditions was attained at the nearby Cape Romain National Wildlife Refuge (a federally mandated class I area).

►There has been a significant decline in the sulfate and total nitrogen deposited from rainfall between 1983 and 2011 on the Francis Marion National Forest.

►Most (64 percent) of the Forest has acidic deposition levels below a level to maintain the long-term health of the ecosystem. About 24 percent of the lands within the proclamation boundary may have excessive acidic deposition. Further soil sampling, ecosystem modeling, and information gathering should be conducted before a final determination can be made on how much more acidic deposition needs to decrease to protect the long-term health of the ecosystems.

Under the 2012 Planning Rule, National Forests and Grasslands are required to consider air quality when developing plan components. As set forth in the rule, air resources should be treated similarly to water and soil resources. The recently proposed planning rule directives require the following to be included in the air quality section of each National Forest's Assessment:

1. Airshed identification;
2. Location and extent of known sensitive air quality areas;
3. Emissions inventories, conditions and trends;
4. Analysis of state implementation plans; and
5. Critical loads identification, as appropriate.

2.2.1.2 Existing Information

Current Forest Plan. The overarching goal regarding air quality in the current Francis Marion National Forest plan is to "take care of the land by continuing to restore and sustain the integrity of its…air". The desired future condition is to maintain air quality, and ensure that air quality near Cape Romain National Wildlife Refuge complements the high air quality standards found at that class I area. The plan recognizes that portions of the Forest may experience some localized and temporary reductions in air quality due to prescribed burning. The Forest plan requires the use of best and emerging smoke management technologies to reduce downwind impacts from smoke and ensure compliance with the Clean Air Act (including visibility at the nearby class I area) and South Carolina's Smoke Management Guidelines. Per the Forest plan, all management activities, not just prescribed fire, should comply with air quality standards.

Current Air Quality Concerns. In addition to causing human health concerns, air pollution can also affect natural and scenic resources such as lakes, streams, plants, wildlife, and scenic vistas. Each year air pollution sources including power plants, industrial facilities, automobiles and wildland fires, release millions of tons of pollutants into the atmosphere. These pollutants, either by themselves or after chemical transformations in the lower atmosphere, can cause negative impacts to ecosystems, including changes to soil and water chemistry from acidic deposition, nutrient enrichment (i.e., nitrogen saturation) from too much nitrogen deposition, impacts to sensitive vegetation due to elevated ozone exposures, and increased visibility impairment (or haze) in scenic areas.

Air pollutants of most concern to natural resources on the Francis Marion National Forest include ozone, particulate matter, sulfur dioxide, nitrogen oxides, and mercury. Ozone is a pollutant formed by emissions of nitrogen oxides and volatile organic compounds in the presence of sunlight. Nitrogen oxides (NO_x) are released when any fuel is combusted at very high temperatures; major sources of NO_x include automobiles, power plants, and industrial boilers. Volatile organic compounds (VOCs) are emitted from both manmade and natural sources, including chemical manufacturing, gasoline-powered vehicles, trees and other vegetation. Research has shown that in the southern U.S. there is an overabundance of naturally-occurring VOCs, and thus ozone formation is "NO_x-limited." This means that the concentration of ambient ozone is primarily dependent on the amount of nitrogen oxide emitted into the air. When ozone is formed, it causes human health concerns as well as negative impacts to vegetation. Specifically, elevated ozone concentrations can reduce the health and vigor of sensitive vegetation and reduce plant growth. The U.S. Environmental Protection Agency (EPA), as directed by Congress, has set a national ambient air quality standard (NAAQS) of 0.075 parts per million (ppm) to protect both human health and the environment.

Particulate matter is a mixture of extremely small particles made up of soil, dust, organic chemicals, metals, and sulfate and nitrate acids. The size of the particles is directly linked to health effects, with smaller particles causing the worst impacts to human health. Additionally, particulate matter is the main cause of visibility impairment. These tiny particles absorb and reflect light which diminishes spectacular views in national forests. Regional haze usually covers large geographical areas, and many local and regional sources of pollution contribute to the degraded visibility conditions. EPA has set NAAQS for ultra-small (less than 2.5 microns in diameter) particulate matter on both a short-term (24-hour) and annual basis to protect human health and visibility. The 24-hour fine particulate matter ($PM_{2.5}$) NAAQS to protect both humans and the environment is currently set at 35 $\mu g/m^3$ (micrograms per cubic meter), while the annual $PM_{2.5}$ NAAQS for human health is 12 $\mu g/m^3$.

Sulfur and nitrogen deposition can cause stream acidification and leaching of important soil nutrients needed for healthy terrestrial and aquatic biota. Nitrogen deposition can also cause eutrophication or nutrient enrichment that negatively impacts water quality, aquatic biota, and may increase invasive plant growth. Sulfur comes primarily from the combustion of coal at electrical generating units. Nitrogen compounds are derived from both the combustion of fuel at very high temperatures (such as in power plants, industrial boilers, and automobiles) as well as from various agricultural processes. Although EPA has considered setting a multi-pollutant NAAQS to address deposition-related affects, they have decided there currently is not enough scientific information to set one standard that would adequately protect the diverse ecosystems across the country.

Mercury is another important environmental contaminant that reaches forests primarily through atmospheric deposition. The primary source of anthropogenic (manmade) mercury is the combustion of coal. Mercury is fairly stable and accumulates in the environment until conditions are right for dispersal. This can occur by wildland fires ejecting the mercury back into the atmosphere, or when associated with wetlands it can be converted via sulfate reduction to its most toxic form, methyl mercury (MeHg). The MeHg is ingested by aquatic organisms and bioaccumulates as it is transported through the food web, and can affect humans when too many fish are consumed in a short period. Unhealthy levels of MeHg have led to fish consumption advisories in almost every state. Methyl mercury has also been found in numerous species of wildlife. EPA regulates the amount of mercury that is emitted into the air from many different sources, including power plants, municipal waste combustors, and medical waste incinerators. Additionally, each state is required by EPA to develop a list of water bodies that do not meet water quality standards—including those impaired by mercury, if applicable—and establish total maximum daily loads (TMDLs) for these waters.

Air pollution can come from local sources, such as activities within the national forests, or may be transported from sources hundreds of miles upwind by weather patterns. Therefore, it is important to identify the airshed around an area of interest, such as the Francis Marion National Forest. An airshed is defined as a geographic area that, due to topography, meteorology and/or climate, is frequently affected by the same air mass. For the purposes of this assessment, the airshed for the Francis Marion is defined as the counties that fall within a 124-mile radius around the Forest. Figure 2-8 shows the counties (shaded) located within 124 miles of the Forest as well as known sensitive air quality areas. These sensitive areas include the location of class I and nonattainment areas within the designated airshed. As shown, the only class I area is Cape Romain National Wildlife Refuge, located just east of the Forest. There is one nonattainment area partially located within the airshed, the Charlotte-Rock Hill Nonattainment Area for ozone. There are no other nonattainment or maintenance areas within the airshed.

Figure 2-8. Map of Francis Marion National Forest airshed (shaded) and known sensitive air quality areas

2.2.1.3 Current Condition and Trends

To assess current air quality conditions and trends on the Francis Marion National Forest, there are four categories of data to examine. The first category involves inventories of emissions from air pollution sources both on and off the Forest. The second category includes measured ambient concentrations of air pollution, especially ozone and fine particulate matter. The third category of data is measured deposition of sulfates, total nitrogen, and mercury. Finally, the last category of data includes any site-specific monitoring of air quality impacts (e.g., ozone surveys) that has occurred on the Forest.

Air Pollution Emissions Trends

The National Emissions Inventory (NEI) (http://www.epa.gov/ttn/chief/eiinformation.html) was used to assess the historic trends of air pollution emissions near the Francis Marion National Forest. Local, state, and tribal air regulatory agencies are required by the EPA to periodically inventory the amount of emissions within their respective jurisdictions. These inventories form the basis for air pollution trends analysis, air quality modeling efforts, and regulatory impact assessments. At this time, the NEI website has inventory data for the years 2002, 2005, and 2008 available for download. County emissions estimates for the 59 counties that fall within 124 miles of the Francis Marion National Forest were downloaded and compiled for each of 3 years.

The pollutants that are of most concern to resources on the national forests are those that have the potential to cause the negative impacts that have been outlined previously in section 2.2.1. Of those, the NEI inventories emissions of sulfur dioxide (SO_2), nitrogen oxides (NO_x), and particulate matter (PM). Table 2-19 shows the total emissions within the airshed for each of these pollutants for 2002, 2005, and 2008.

Table 2-19. Emission of sulfur dioxide, nitrogen oxides, and particulate matter within the airshed for the years 2002, 2005, and 2008

Pollutant	Emissions (tons/year)			Percent (%) Change in Emissions (2002–2008)
	2002	2005	2008	
Sulfur Dioxide (SO_2)	382,580	380,422	260,698	-31.8%
Nitrogen Oxides (NO_x)	425,217	386,348	350,047	-17.7%
Particulate Matter < 10 µm in diameter (PM_{10})	347,000	352,730	329,259	-5.1%
Particulate Matter < 2.5 µm in diameter ($PM_{2.5}$)	103,769	112,506	114,651	+10.5%

The reductions identified above mirror national trends as outlined in Our Nation's Air: Status and Trends through 2010 (http://www.epa.gov/airtrends/2011/report/fullreport.pdf). Since 1990, annual emissions of SO_2 have declined by more than 60 percent, while emissions of NO_x have fallen by more than 40 percent in the United States. These reductions have taken place despite increases in population, energy consumption, and the number of miles driven. Figure 2-9 shows these trends. Trends on mercury emissions, another pollutant of concern, have been difficult to evaluate due to the lack of appropriate emission factors, lack of speciated data, and lack of acceptable tests for mercury-emitting sources (South Carolina Mercury Assessment and Reduction Initiative, 2010).

Emission reductions over the past decade have been achieved as a result of new regulations, voluntary measures taken by industry, and the development of public-private partnerships. It is expected that air quality will continue to improve as recently adopted regulations are fully implemented, and as a result, it is anticipated that emissions of air pollution released within 124 miles of the Francis Marion National Forest will continue to decline.

In addition to emissions of sources near the Forest, emissions from Forest activities, specifically prescribed fire, were calculated. Figure 2-10 shows the trends in fine particulate matter emissions from prescribed fires on the Francis Marion National Forest from 2006 through 2011.

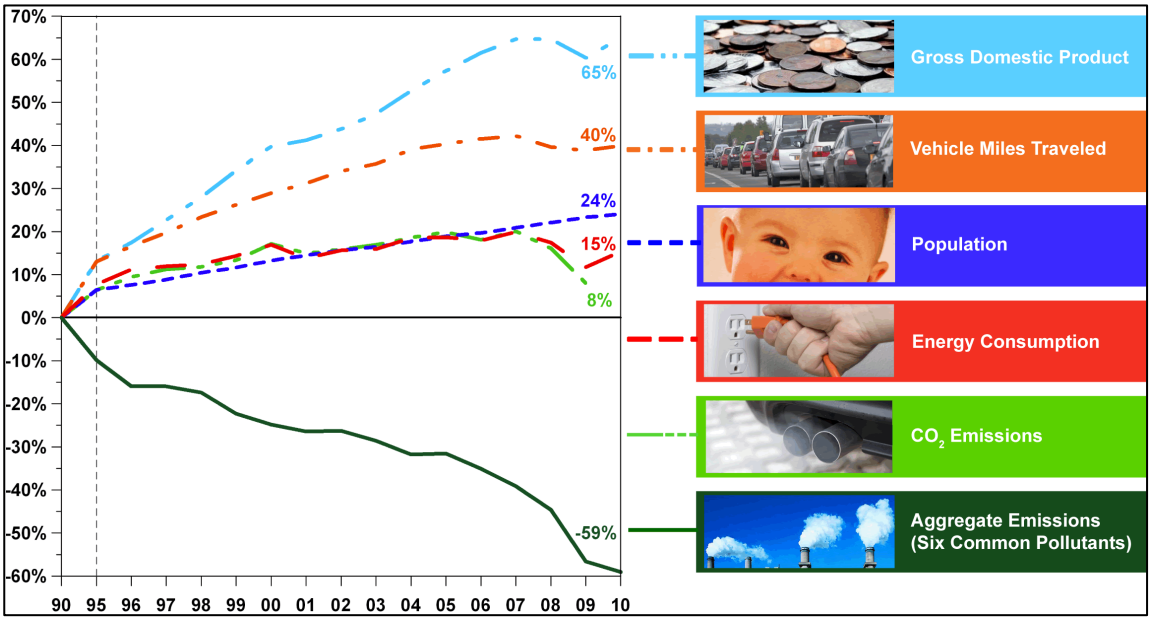


Figure 2-9. Comparison of growth measures and emissions, 1990–2010

Source: http://www.epa.gov/airtrends/2011/report/fullreport.pdf

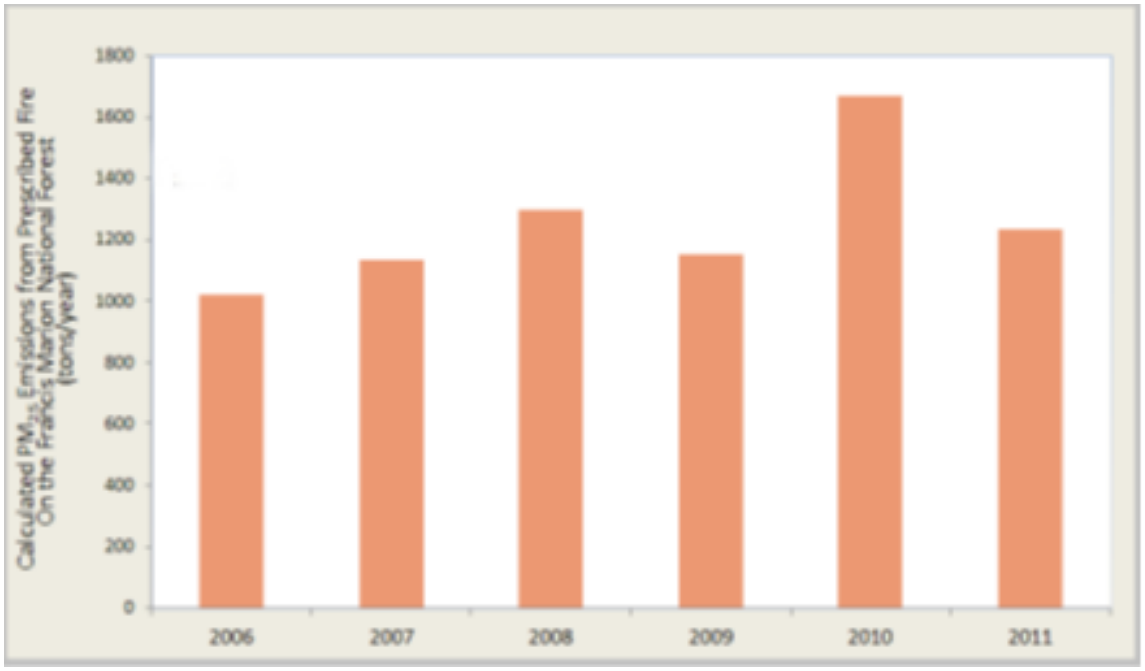


Figure 2-10. Emissions of fine particulate matter from prescribed fires on the Francis Marion National Forest, 2006–2011

Ambient Air Quality Trends

Ambient concentrations of air pollutants, including ozone and fine particulate matter, are measured by the South Carolina Department of Health and Environmental Control (SC DHEC) at locations near the Forest. Figure 2-11 displays the location of the monitoring sites used in this assessment. This includes ground-level ozone concentrations at two locations and fine particulate matter monitoring at two locations near the Forest. The measurements are compared to the appropriate NAAQS to assess whether air quality is healthy or not.

Figure 2-11. Location of ozone and fine particulate matter monitoring sites used in this assessment of air quality

Figure 2-12 shows the ozone concentrations at two monitoring sites close to the National Forest. The measured concentrations (blue open circles) for the years 2004–2012 are compared to ozone NAAQS (red line), and results are also given on the statistical trends. Ozone monitors near the Francis Marion National Forest have not exceeded the current ozone standard since 2005. Ozone levels appear to be fairly level, with no statistically significant trend either upward or downward. EPA is required to reassess the standards every 5 years based on most recent scientific research, and as a result more stringent standards may be proposed sometime in the future.

Figure 2-13 shows the fine particulate matter concentrations at monitoring sites close to the National Forest. The measured concentrations (open blue circles) for the years 2004–2012 are compared to both the daily (24-hour) and annual NAAQS (red lines). The monitors near Francis Marion National Forest have not exceeded either the daily or the current annual fine particulate matter standard since 2006. Levels of ambient fine particulate matter are experiencing a statistically significant downward trend over the same time period. As with ozone, EPA is required to reassess the standards every five years based on most recent scientific research, and as a result more stringent standards may be proposed sometime in the future.

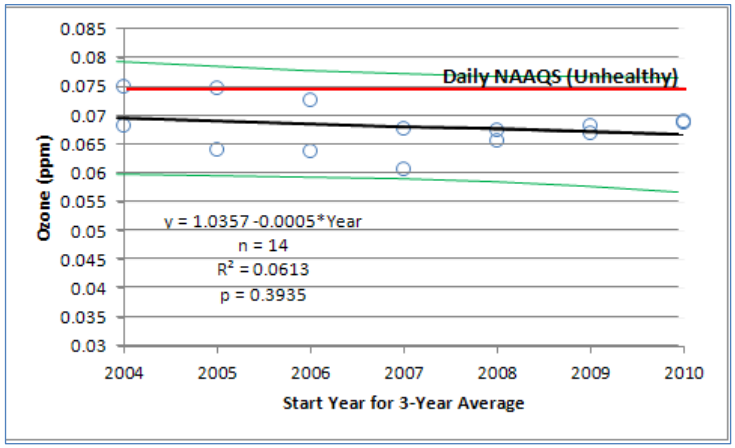


Figure 2-12. Statistical trend in ozone near the Francis Marion National Forest

Note: The blue open circles are the 3-year average of the 4th highest ozone concentrations at the monitoring sites in Berkeley or Charleston counties. The black line is the predicted values for ozone, while the green lines are the 95% confidence intervals for the estimate. The red line is the current National Ambient Air Quality Standard (NAAQS). The downward trend of ozone is not significant (p >0.05). The unit of measure is parts per million (ppm).

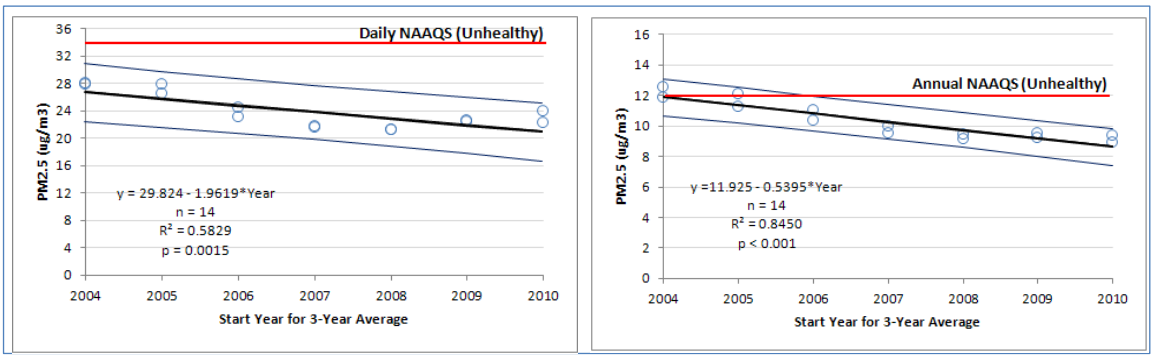


Figure 2-13. Statistical trends in fine particulate matter ($PM_{2.5}$) near the Francis Marion National Forest for the daily (left) and annual (right) National Ambient Air Quality Standard (NAAQS)

Note: The blue open circles are the 3-year average of the concentrations measured at the monitoring sites in Charleston County. The black line is the predicted values for ozone, while the blue lines are the 95% confidence intervals for the estimate. The red line is the current NAAQS. The downward trend in fine particulate matter is significant (p <0.05). The unit of measure is micrograms per cubic meter (µg/m3).

Deposition of Sulfates, Total Nitrogen, and Mercury

Acidic (sulfur and nitrogen) compounds can be deposited from the atmosphere in a dry form (first seen as haze), in rainfall (wet), and in clouds or fog. Most of the deposition of sulfates and total nitrogen (nitrates and ammonia) on the Francis Marion National Forest occurs in the rain. The National Atmospheric Deposition Program (NADP) provides a long-term record of acidic deposition at sites located throughout the United States and monitoring of deposition has occurred on Cape Romain National Wildlife Refuge since the year 2000. The NADP acidic deposition data was combined with precipitation and other data to statistically estimate the Forestwide annual sulfate and total nitrogen deposition from rainfall for the years 1983 through 2011 (Grimm and Lynch 2004).

Sulfates are the most abundant acid compound deposited from the atmosphere and they continue to impact the soils on the Francis Marion National Forest. In 1983, the amount of sulfate deposition from the rainfall was greater than 12 kilograms per hectare (which is roughly equivalent to 12 pounds per acre) with the greatest deposition occurring in the northwest corner of the Forest. Sulfur dioxide (the precursor to sulfates) has decreased significantly since 1977 and the 2011 estimated sulfate deposition for most of the Forest was 9 kg/ha or less (Figure 2-14). Figure 2-15 shows that Forestwide annual average sulfate and total nitrogen deposition from rainfall has significantly declined between 1983 and 2011.

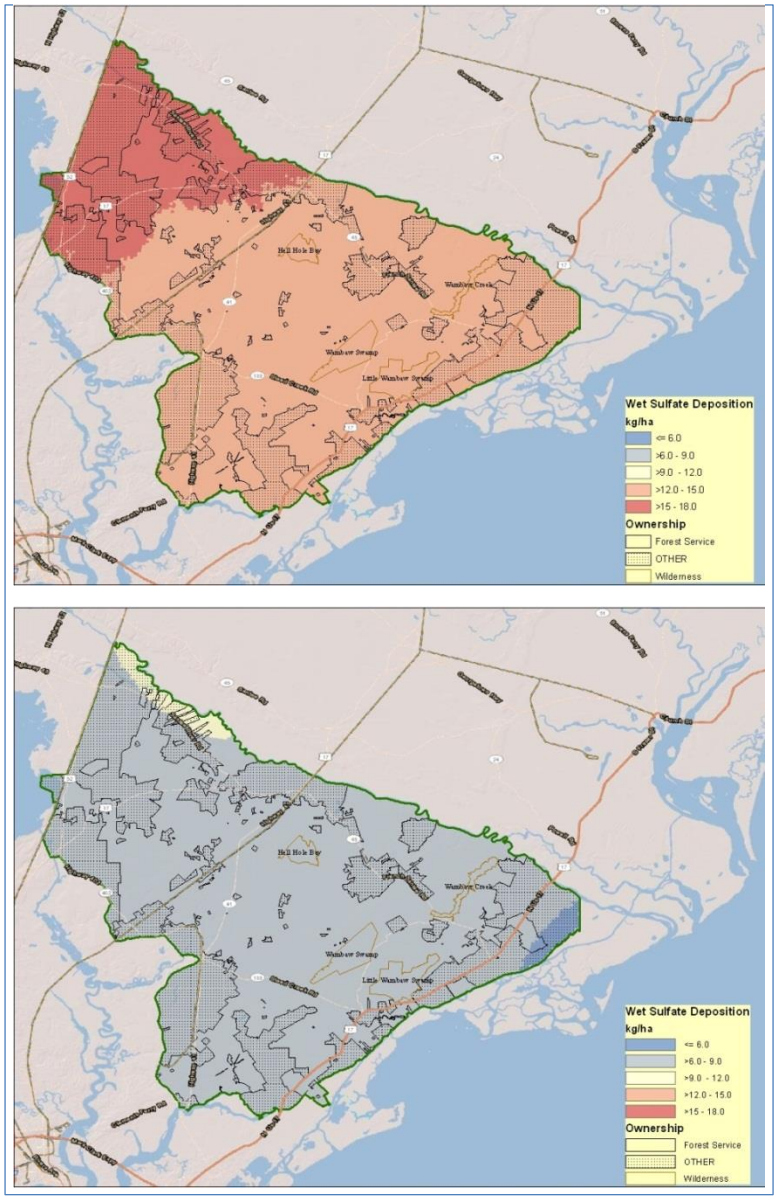


Figure 2-14. Estimated Forestwide wet sulfate deposition for 1983 (top) and 2011 (bottom) have shown a significant decline

Note: The unit of measure is kilograms per hectare (kg/ha). One kg/ha is approximately the same as one pound per acre. Deposition estimates based upon the approach used by Grimm and Lynch (2004).

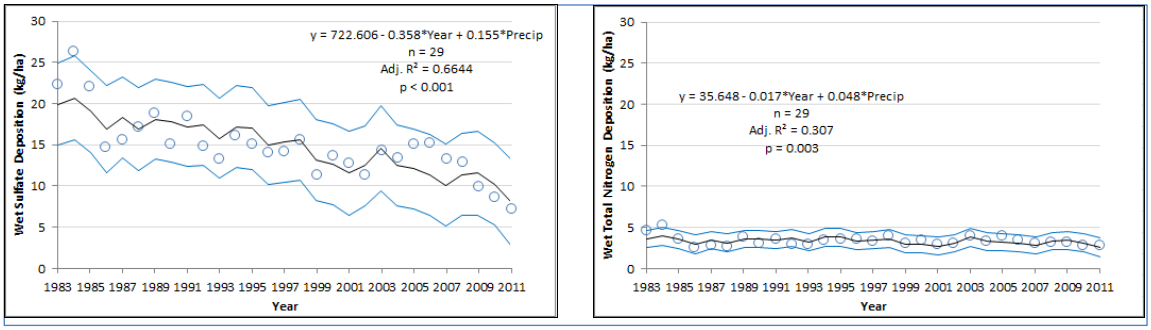


Figure 2-15. Trends in the average annual sulfate (left) and total nitrogen (right) wet deposition estimates (blue open circles) within the Francis Marion National Forest proclamation boundary

Note: From Grimm and Lynch (2004). The black line is the predicted wet sulfate or total nitrogen deposition, while the blue lines are the 95% confidence intervals for the estimates. The downward trend in wet sulfate and wet total nitrogen deposition is significant (p <0.05). The unit of measure is kilograms per hectare (kg/ha). One kg/ha is approximately the same as one pound per acre.

Another air pollutant that can be deposited and have a negative impact on the ecosystem is mercury. Once mercury deposition occurs, it is often transformed by wetlands into methyl mercury (MeHg), which bioaccumulates in fish. Wetlands, which are found throughout the Francis Marion National Forest, are important sinks for mercury, as well as sources of methyl mercury. Fish consumption advisories are common throughout coastal South Carolina due to methyl mercury, as shown in Figure 2-16. The National Water-Quality Assessment Program (NAWQA) established by the U.S. Geological Survey found that the Santee Basin (which includes the Forest) has the highest methylation efficiency in the nation.

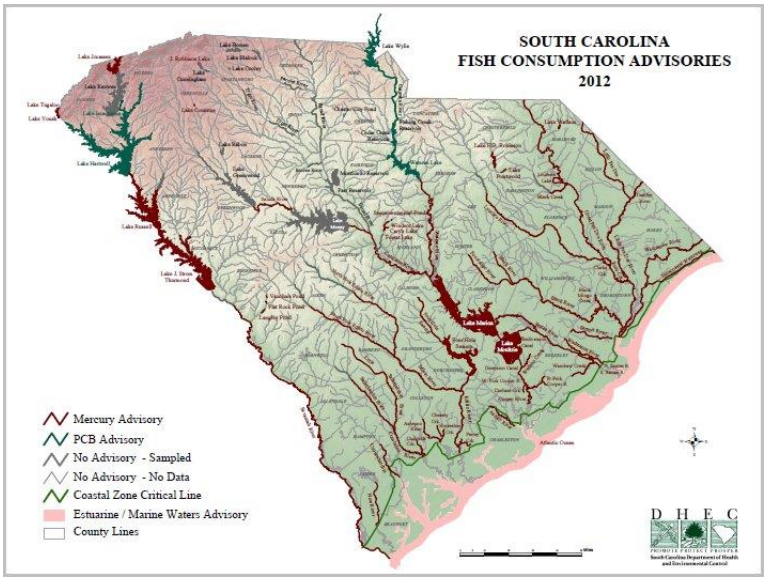


Figure 2-16. Fish consumption advisories in South Carolina

Source: http://www.scdhec.gov/environment/water/fish/docs/map.pdf

NADP operates the Mercury Deposition Network (MDN) which provides data on geographic distributions and trends of mercury in precipitation. MDN has operated a site on Cape Romain National Wildlife Refuge since 2004. Results from the monitoring

(http://nadp.sws.uiuc.edu/mdn/) indicate that Cape Romain (and likely the nearby Francis Marion National Forest) receives more than 10 micrograms per square meter of mercury deposition.

In the past, South Carolina has recognized that many water bodies within the State, including those adjacent to the Francis Marion, do not meet state water quality standards for mercury (http://www.scdhec.gov/environment/water/tmdl/docs/tmdl_06-303d.pdf). More recently, SC DHEC has listed mercury as a 303d pollutant, but has not included the parameter of mercury when setting forth TMDLs, because procedures to deal with this pollutant have not been developed (http://www.scdhec.gov/environment/water/tmdl/tmdlsc.htm).

Site-specific Monitoring

As part of the "Wilderness Challenge," in 2011, an ozone biomonitoring project was implemented on the Francis Marion National Forest in four wilderness areas: Hell Hole Bay, Wambaw Swamp, Little Wambaw Swamp, and Wambaw Creek. The purpose of the project was to determine whether ozone exposures in the wilderness areas, as measured via symptoms, where causing a physiological response to sensitive vegetation. Nearby ambient monitoring data were also utilized to examine if ozone exposures could be causing biomass reductions to tulip poplar (an ozone sensitive species). The results of this project indicate that ozone is causing minimal impacts to sensitive vegetation occurring in these wilderness areas (Stratton 2011).

Other water inventories and assessments near the wilderness areas have focused on mercury and methylmercury in fish, rather than acid deposition. In 2003, Koman and Hanson reported on the status of water quality information on the Forest and focused on parameters such as fecal coliform, dissolved oxygen, conductivity and salinity, total mercury and methylmercury in fish, mud, and water (Koman and Hanson 2003).

Involvement with State Implementation Plans for Regional Haze

The USDA Forest Service is cooperating with the SC DHEC and other air regulatory agencies to identify air pollution emission reduction strategies to achieve natural background visibility at federally mandated class I areas. Additionally, the Forest Service has worked with the Regional Planning Organization (VISTAS) to ensure that emissions from Forest Service activities, especially prescribed fires, are included in the emissions inventories for the respective state implementation plans (SIPs).

Measurements of visibility-impairing pollutants are made at the IMPROVE (Interagency Monitoring of Protected Visual Environments) site located at Cape Romain National Wildlife Refuge, a federally mandated class I area, just to the east of Francis Marion National Forest. The IMPROVE monitor measures the concentration of different types of fine particles and these measurements are used to estimate visibility in deciviews. Each change in deciview is equivalent to a noticeable change in visibility; higher deciview values indicate hazier conditions, while lower values signify clearer air. The IMPROVE data are used to determine whether visibility is improving at the level required by the Regional Haze Rule. The Regional Haze Rule established a uniform rate of progress, also called a glide path, for each class I area to measure if enough progress is being made to meet natural background conditions by the year 2064. Figure 2-17 shows the 5-year average haziness index (light blue line) at Cape Romain National Wildlife Refuge increased above the glide path (pink line), but recently improved for the most recent 5-year average to match the glide path required by the Regional Haze Rule.

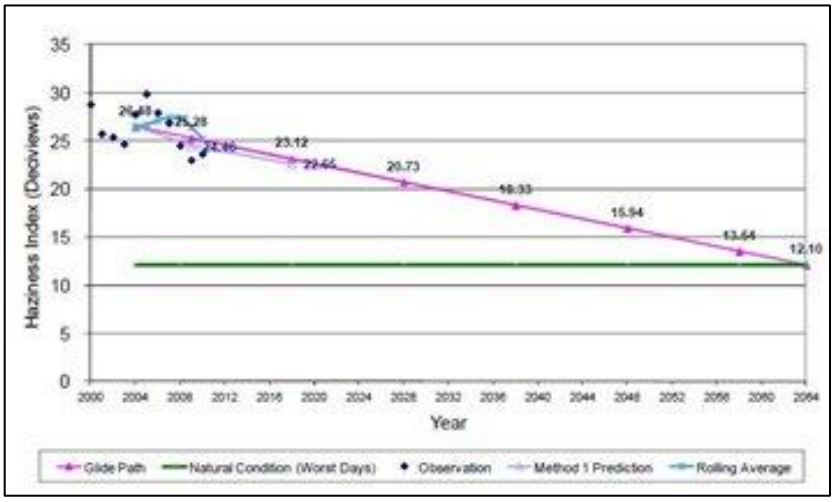


Figure 2-17. Measured visibility (worst visibility days) as compared to the glide path at Cape Romain National Wildlife Refuge Class I Area

Source: SC SIPR: Regional Haze Periodic Report

National and regional databases are weak at providing estimates of the amount of air pollution emissions from prescribed fires. To overcome this weakness, the USDA Forest Service assisted the VISTAS and the state air regulatory agencies by providing information on the time of the prescribed fires, location, and size of prescribed fires that occurred in 2002 and estimates for 2018. There were an estimated 23,962 blackened acres in 2002 and by 2018 the number of acres is projected to increase to 45,206 acres (Figure 2-18). The estimated number of blackened acres has been less than 45,000 acres between 2005 and 2011, except there were 50,569 blackened acres reported in 2010. Figure 2-17 shows the 2010 observed haziness index (blue dot) was below the glide path, which indicates the higher than projected blackened acres from prescribed fires in 2010 did not impede the regional haze goal at Cape Romain National Wildlife Refuge.

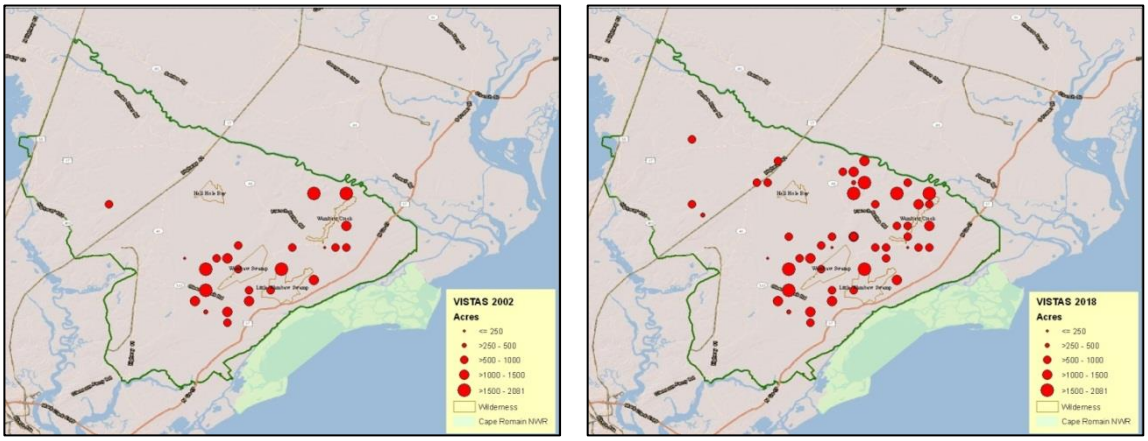


Figure 2-18. Location of prescribed fires in 2002 and those planned for 2018 on the Francis Marion National Forest

Note: The data was utilized in an atmospheric dispersion modeling analysis to evaluate if visibility at Cape Romain National Wildlife Refuge is predicted to improve by 2018.

Critical Loads for Soil Acidification on the Francis Marion National Forest

Many people are concerned that acidic deposition has and will continue to severely impact the health of terrestrial and aquatic resources. The deposition of sulfur and nitrogen compounds from the atmosphere can accelerate the loss of base cations (calcium, magnesium, and potassium) from the soils. Adequate supplies of base cations are needed in the soil to maintain healthy forests. One question that may be asked: Is the current sulfur and nitrogen deposition exceeding a level where no harm is likely to occur to sensitive components of the ecosystem? The total amount of sulfur plus nitrogen deposition that can be tolerated is called a critical load and it can be established to protect forest soils and/or sensitive biota. Current scientific knowledge is to be used when establishing critical loads for acidification. Estimates developed by McNulty et al. (2007) are being used in this assessment to identify if acidic deposition on any areas on the Francis Marion National Forest is exceeding the critical load.

McNulty et al. (2007) calculated the steady state critical load by obtaining spatial information for the Francis Marion National Forest. Estimates for some of the information needed included:

1. The annual amount of base cations (calcium, magnesium, potassium, and sodium) deposited from the atmosphere.
2. The base cation (calcium, magnesium, and potassium) weathering rate based upon the percent clay in the soils, and the parent geology.
3. The amount of base cations and nitrogen removed from a site when periodic timber harvesting occurs.
4. The amount of inorganic nitrogen deposited from the atmosphere that is converted to organic nitrogen in the soils.
5. The average annual runoff based upon data collected between 1951 and 1990.
6. The critical base cations to aluminum ratio that was set to 1.0 for conifer forests and 10.0 for deciduous forests.

The information obtained for these variables, along with others, were used in an equation to estimate the forest soil acid load. McNulty et al. (2007) subtracted the forest soil acid load from the average (1994–2000) annual acidity deposition estimates (sulfur plus nitrogen). Values that were zero or a negative number means the deposition of acids from the atmosphere did not exceed the calculated forest soil acid load; whereas values above zero indicate the average acidic deposition exceeds the amount the soils can buffer to maintain the long-term health of the ecosystem. Table 2-20 and Figure 2-19 show the acidic deposition does not exceed the critical load for most (64 percent) of the area within the proclamation boundary. This is expected because large portions of the Forest soils are derived from limestone or other carbonate sources (Cameron and Martin 1984), which account for the high presence of base cations in the soils. About 25 percent of the soils are being impacted by total acidic deposition above the critical load and most (15 percent) is Forest Service ownership. Table 2-20 shows that acidic deposition has been significantly decreasing since 2000. Calculations performed for this assessment estimate that there may have been an additional annual average reduction of 96 equivalents per hectare per year (eq/ha/yr) between 2005 and 2011 when compared to 1994 to 2000. Even with this reduction there will still be at least 18 percent of the area where the acidic deposition is exceeding the critical load.

Table 2-20. Percentage of ownership in each of the soil acidic deposition critical load exceedance categories based upon McNulty et al. (2007)

	Ownership (%)		
Acidic Deposition Exceedance	**Forest Service**	**Other**	**Total**
No Exceedance	43.23	20.87	64.10
0–250 eq/ha/yr	4.17	2.62	6.79
250–500 eq/ha/yr	11.17	7.01	18.18
No Estimate	3.68	7.25	10.93

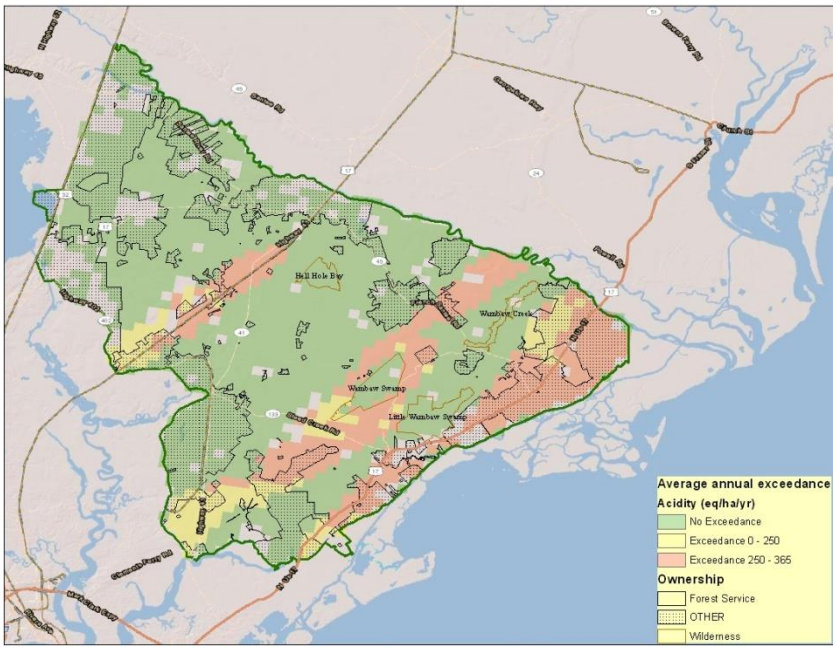


Figure 2-19. Areas (yellow or red) where the average (1994–2000) atmospheric sulfur plus nitrogen deposition exceeds the soils critical loads

Note: Spatial data following McNulty et al. (2007); the units of measure are equivalents per hectare per year (eq/ha/yr).

Caution should be used when interpreting these critical load exceedance results. First, McNulty et al. (2007) were providing initial estimates for the conterminous United States to "… locate forest soil areas that could potentially be in exceedance of the…" critical load. Second, the deposition of sulfur and nitrogen compounds has decreased since the McNulty et al. (2007) was completed. Finally, steady state critical loads do not take time into consideration; although critical load exceedances indicate the potential for ecosystem damage, this damage may not be currently ongoing, and may not occur for centuries. Therefore, establishing an acidic deposition target load is not recommended for the Francis Marion National Forest, until further soil sampling and other site-specific measurements are conducted within the areas (Figure 2-19) identified as exceeding the critical load. The critical load exceedances calculated by McNulty et al. (2007) can be used to develop monitoring plans to verify critical load exceedance calculations.

2.2.1.4 Information Needs

The review of current conditions and trends on the Francis Marion National Forest shows that mercury deposition may be having an effect on both water and aquatic fauna, although SC DHEC's decision to not include mercury as a parameter in recent listing of impaired waterbodies may indicate that the situation is improving. At the same time, several of the blackwater areas on the Forest are affected by fish-consumption advisories due to mercury. However, measurement of mercury and its impacts are expensive and require exacting sampling techniques most appropriately done in conjunction with research scientists. At this time, the Forest Service has not adopted a standard protocol for measuring and monitoring the effects of mercury, and therefore, specific recommendations on monitoring the effects of mercury have not been made. Considering the impact mercury deposition might be having, the Forest may want to look for additional opportunities to partner with the State or a research group to measure impacts on Forest Service ownership, especially any which are dominated by wetlands.

An initial estimate suggests that about 15 percent of the Forest Service ownership on the Francis Marion National Forest is exceeding critical loads of acidity, indicating the potential for harm to sensitive components of the ecosystem. However, the results in this assessment should not be used to establish a target load. Instead, further soils and other data collection should be obtained and used in an ecological model to estimate more precisely when unacceptable impacts are likely to occur, and what level of acidic deposition can be tolerated so there are no impacts to forest soils and/or terrestrial or aquatic biota.

2.2.2 Soil

2.2.2.1 Preliminary Findings

►According to existing soils data, nearly 56 percent of the Forest is considered to be hydric (see Figure 2-20). Hydric soils include: poorly drained and very poorly drained.

►A large portion of hydric soils have had some type of drainage modification. The extensive hydrologic modifications across the landscape were not always evident in past soil mapping activities. Some changes in soils may have resulted from the past drainage, diking, and associated activities that will be only evident at project- or site-level inspections.

►Soil classification could have changed in some areas, mainly in bays and swamps, due to high fire burn severity.

►Monitoring of soils was not addressed in the 1996 Forest plan and would not meet requirements in the 2012 Planning Rule. In order to track changes to the soil resource in the future more effort needs to be made to complete the USDA Forest Service soil quality monitoring process (USDA Soil Management Manual 2010).

►New information, such as LiDAR, is now available and is being used to update the soil map for the Forest. This update will create more precise soils maps that can be used to analyze impacts from site-specific projects.

►Ruts from past harvesting operations including post-Hugo salvage are prevalent across the landscape. Depending on the severity, these ruts likely interrupt local surface and subsurface hydrology.

2.2.2.2 Existing Information

Direction in the Francis Marion Forest plan is found in different sections:

Desired Future Conditions (page 1-5, Francis Marion Forest plan). "Soil productivity is maintained. Soil quality and nutrient cycling processes are maintained. Large woody debris, leaf litter and other organic matter are retained on many areas to fulfill an important ecological role in providing soil organic matter, plant nutrients, and energy for soil micro-organisms. Soil structure is maintained except for areas such as construction sites, roads, skid trails and some log landing areas."

Forest-wide standards are included in chapter 3 of the 1996 Francis Marion Forest plan. Some Forest-wide standards to protect soils are included here, but see the 1996 Forest plan for a complete list:

- FW-101 Avoid construction (roads, trails, recreational sites, etc.) in floodplains and wetlands whenever there is a practical alternative.
- FW-102 Restore primary skid trails and log landings on soils with sandy loam to clay textures within 10 inches below soil surface (i.e., smooth out and fertilize primary skid trails and fertilize log landings) to minimize loss of soil productivity and water quality as needed.
- FW-103 Install adequate road drainage structures to provide for normal surface water movement.
- FW-105 Locate skid trails, log landings, and log ramps on wet sites and riparian areas according to the following criteria, and only as designated by a Forest officer.

  a) Locate permanent log landings on elevated terrain generally at 0.5-mile intervals.

  b) Limit concentrated skid trails and log landings to no more than 10 percent of an area so that compaction and other disturbance will be contained to only those areas disturbed.

  c) Construct log ramps on the best drained sites to facilitate access to log landings from system roads and to minimize skidding distance.

  d) The number of log landings will be the minimum needed to harvest any area.
- FW-106 Prevent and minimize the effects of soil compaction, rutting, and puddling during activities through the use of low ground pressure equipment, aerial systems, activity suspension or other soil protection measures as mats, bridges, woody fill, etc., when saturated or wet soil conditions cannot be avoided. Indicators that may signal caution include (1) the water table within 18 inches of the surface; (2) difficulty in walking across the site without compacting, seeing or hearing surface or groundwaters under foot; (3) presence of wetland indicator plant species, hydric soils and/or saturated or flooded hydrologic conditions during activity, and (4) events which flood or saturate soils.
- FW-107 Avoid direct application of fertilizer to water bodies including streams (unless prescribed for wildlife habitat improvement).

The Forest has developed an agreement with the Natural Resource Conservation Service (NRCS) in South Carolina to update the Francis Marion National Forest soil maps. Through the agreement, parties will also install water wells on the Francis Marion in order to monitor shallow water table levels which will aid in forest management recommendations. Collaboration between the Forest and the NRCS is expected to continue for years to come.

Forest managers collaborate with researchers from the Santee Experimental Forest on issues related to watershed management.

2.2.2.3 Current Condition

Soil is a collection of natural bodies that consists of organic matter, minerals, living organisms, and is capable of supporting a wide variety of biological, chemical, and physical processes. Soil is a result from the weathering of parent material over extended periods of time. Physical components of soil include various sizes of a mineral component, organic matter, water, and air.

The Forest lies within the Sea Island section of Atlantic Coastal Plain Physiographic Region. Soils of this region have formed in marine and fluvial sediments that were deposited during the Quaternary period and are Pleistocene in age (SCDNR). Within the Francis Marion soils may encompass any given percentage of organic matter, sand, silt, and clay which may occur in various combinations and depths. Soil horizon development has been influenced by climate, living soil organisms, and relief. Also, soils within the Forest have been influenced overtime by cultural alterations. For instance, dikes and dams used to flood rice fields have altered the hydrology of the area, which in turn affected soil development and quality.

A 2nd order soil survey has been used to delineate and identify specific soil series and their boundaries within the Forest. At this level the minimum mapping unit typically ranges from 2 to 8 acres, so local inclusions of other soil types within a mapping unit may be found. Currently, there are 77 map units identified on the Forest (SSURGO 2013). Landforms in which these map units occur on include ridges, marine terraces, Carolina bays, swamps, pocosins, depressions, flats, and floodplains. Elevations of these landforms range from 5 below to 81 feet above sea level. Drainage class of these soils range from excessively well drained to very poorly drained.

Soil function is ecosystem-specific and must be assessed in the context of desired ecological condition (Burger et al. 2010). Eighteen ecological systems have been identified for the Forest plan revision (Simon and Hayden 2013). Due to the lack of soil quality data for each of these ecological systems and since soil types, their properties, and processes vary greatly, a comprehensive assessment of soil quality has not been possible and contributes uncertainty. Also, some management goals may not be completely complementary with respect to soil quality; one goal may, in fact reduce soil quality for another goal. Therefore, an assessment of soil quality and current conditions are discussed in general.

Soil quality has been defined as its ability to provide services important to people. It is useful as a measure of the extent to which a managed soil is improved or degraded from its natural state or some other selected reference condition (Burger et al. 2010). Although there is no data to compare soil function today to its function in a natural setting; overall soil quality within the Forest is considered to be adequate. However, soil quality may be less than adequate for the current desired condition in some areas due to soil disturbance from past land management practices.

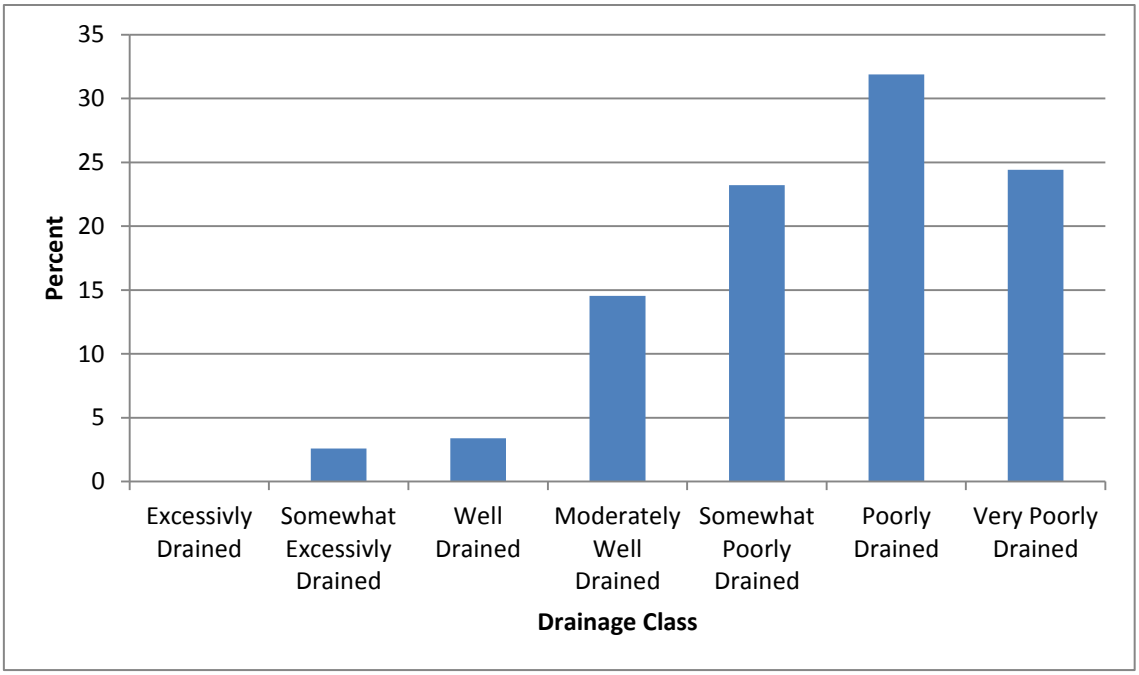


Figure 2-20. Drainage class distribution for soils within the Francis Marion National Forest

Past land management practices have most likely altered soil hydrology more than any other soil attribute. Throughout the Forest water tables are typically close to the surface and soils with restricted drainage are common (NRCS 2010a). Many areas with these characteristics show signs of skid roads, rutting, compaction, and soil displacement. These areas are the remnant effects of the Hurricane Hugo salvage and other past operations that occurred when conditions were unsuitable for the use of mechanical equipment. The portion of these areas that were compacted and rutted now holds water for extended periods of time. Alterations to soils have been found to occur more frequently on hydric soil types, which comprise approximately 56 percent of the total land area of the Forest. A large portion of hydric soils has had drainage modifications that include channelizing streams, drainage ditches, and forestry bedding.

In general, soils have not changed very much since the last Forest plan revision. There are localized changes due to management activities that disturb the soil surface, but generally changes in soil properties are more static. Occasionally, during dry weather patterns, wildfires and some prescribed fires enter into areas that are normally wet and burn several inches of accumulated organic material. Depending on the degree of change, soils in those areas function differently than before the fire and may also be taxonomically different. These changes are not regularly monitored or documented except in some wildfire instances where a damage assessment associated with a burned area emergency response report was completed.

Overall, most soils are adequately fertile; however, the poorly drained soils have low fertility levels and hydrous oxides of iron and aluminum that cause some restrictions on pine tree growth. Soils within the Forest are stable with little erosion occurring across the area.

Soils are intact and serve as a medium for root growth and soil organisms. Soil organisms are vital to decomposition and cycling of plant and animal materials in soils; however, the exact role of soil biological communities in maintaining soil quality is unclear (Levi 2007). The rapid carbon assessment done by the NRCS show soil organic carbon stocks are considered to be

between 1,001 to 1,200 mg/ha to a depth of 100 centimeters (soil survey staff, RaCA project). In forest soils, nutrient supply and biological activity are intimately tied to organic matter and nutrient cycling processes, including rates of input, decomposition and mineralization, storage, and release or uptake. Protection of these processes from soil surface disturbances, displacement of soil organic matter layers, and severe burns should maintain function in a given soil of a certain ecosystem.

2.2.2.4 Information Needs

The current soil map for the Forest is being updated and should be finalized during 2014. Also, an ongoing soil updating process will be needed in the future. As the technology changes and the Forest incorporates new information, such as LiDAR, soil maps will become more precise.

In order to track changes to the soil resource in the future, more effort needs to be made to complete the soil quality monitoring process.

2.2.3 Water Resources and Quality

2.2.3.1 Preliminary Findings

►Information sources suggest blackwater streams with headwaters in wetland areas produce methyl mercury through sulfate reduction. Methyl mercury can bioaccumulate and has contributed to fish consumption advisories in certain predatory fish species (Plewa and Hansen 2003; SC DHEC 2012; SCDNR 2013). Other connected species that feed on aquatic organisms from blackwater streams may also be affected according to some sources (Wikipedia 2013). The SCDNR 2013 fish consumption advisory map identifies the main streams, but smaller streams are suspect.

►Water quality total mean daily loads (TMDLs) have been identified for action for fecal coliform and methyl mercury on select stream systems with the watersheds on the Francis Marion National Forest. Fecal coliform is a particular concern within the tidal shellfish gathering waters. Feral pigs are an introduced source of fecal contamination that could be influenced by continued treatment by the Forest Service. It is uncertain how much Forest management activities and the legacy of hydrologic modifications has contributed to the movement of fecal coliform and methyl mercury within the forest environment. The State of South Carolina may need to work with Forest personnel on corrective actions, but no actions have been indicated at this time.

►Salt or brackish water influences are known along the Santee River and lower tributaries due to the low flow periods from the Santee Cooper Dam Project, particularly during high tide periods with new and full moons, high eastern winds, tropical or hurricane winds (Hansen 2008). In addition to this, sea-level rise may influence about 4 to 5 percent of the Forest with habitat type changes over the next 50 to 100 years, using the A2 model maximum extent that addresses a 0.74 meters (30 inches) sea level rise over 100 years. The limit of the various models over the 100 year period is 2 meter increase in sea level. The model also considers erosion and accretion of land as a result of the increased tidal influence. Most of the changes are undeveloped upland forest to shrub/scrub transitional marsh (TACCIMO-SLAMM 2013). These conditions of sea level change have a substantial degree of uncertainty as to their extent, but will locally impact instream water quality and have the potential to modify aquatic, marsh, maritime and freshwater habitats. More detail is discussed in the climate change section.

►The stream network, location, permanence of flow indicators, and channel type based on existing mapping should be updated for the Forest plan revision. Improvements based on LiDAR are forthcoming. A degree of uncertainty will remain with the application of the newly derived data, but the improved outputs will be more consistent with field conditions.

►In comparing reference, desired, and existing condition, past hydrologic modifications have altered stream, riparian and wetland conditions. The majority of the hydrologic modification included drainage or impounding for agriculture. Little direction was mentioned in 1985 or 1996 plans or limited analyses about effects of past actions relative to altering hydrology. It is uncertain about how much impact these modifications continue to have on water flows, aquatic habitats, riparian areas, and other resources. There have been no efforts to determine their impact or diffuse their effectiveness. It is unlikely that they would naturally restore themselves and the assumption is they continue to modify the hydrology. This lack of information is a gap in knowledge, but the plan will consider and include the potential for hydrologic restoration to benefit forest resources.

►Limited direction was mentioned in earlier Forest plans about tidal areas, which include tidal swamps, salt or brackish marsh, transitional marsh and estuary. TACCIMO-SLAMM suggested there are about 8,000 acres that have some degree of tidal influence in the next century. This estimate may not include the full extent of effected areas in the Santee River and tributaries such as Wambaw Creek. About 5,000 acres may be influenced in sea-level rise over the next 50 years. Hydrologic modifications complicate and add uncertainty. Added attention to tidal areas and critical habitats may be warranted in the plan revision. Outside funds may be available to help restore critical habitats and streams which have been affected.

►Hydrological modifications may have altered the hydration of riparian areas and wetlands. As a result, vegetation types, fire regime, fuel hazard, and their natural ability to serve as fuel breaks or protective buffers from development within the urban interface may have been reduced. Retaining large wood in streams depends on saturation, limited fire, and a continuing source of new wood. Conditions that favor rehydrating the floodplain and encouraging large wood entry into stream systems may help retain large wood and improve stream permanence. Besides benefits to water quality and aquatic habitats, there may be benefits to provide a more natural fuel break between Forest and private lands.

►The 1996 plan did not recognize the effects relative to the Intercoastal Waterway, major dams, channel dredging of Cooper River, former dredging to improve access to tidal areas, or similar activity within the area immediately adjacent to the Francis Marion National Forest. Some of these actions are history, and some are ongoing with respect that they are periodically maintained. There is a degree of uncertainty relative to extent and degree these outside activities have affected the Forest.

►Nationwide efforts for the development of National BMPs (best management practices) are in various stages of development and implementation. The new National BMP Program consists of four components: (1) the National Core BMP Technical Guide (Volume 1; FS-990a, April 2012); (2) the National BMP Monitoring Technical Guide (Volume 2; FS-990b, in development); (3) revised national directives in FS Manual and Handbook; and (4) a national data management and reporting system. The National Core BMP Technical Guide (Volume 1) was published in 2012 and the National BMP Monitoring Technical Guide (Volume 2) expected in 2013. The revised directives are needed to provide clear direction for implementation of the National BMP Program and would allow the Forest Service to address implementation of the National BMP Program on its lands in a consistent manner. The proposed directives require the Forest Service

to implement the National Core BMPs, conduct implementation and effectiveness monitoring, and report on and evaluate monitoring results.

However, at the state and Forest levels, since SC BMPs for Forestry were developed in 1994, management measures in the Coastal Zone Management Act, the 1996 Francis Marion plan standards and guidelines, and the 2002 Region 8 Soil and Water Conservation Practices Guide have been guiding Forest operations. South Carolina Forestry Commission and Forestry Association, in cooperation and support from industry, Clemson University and the US Forest Service have intended to set an industry standard by designing and implementing BMPs to protect water quality, beneficial uses of water and as needed, provide stewardship-based information including measures needed to conserve soils, wetlands, streams, wildlife habitat and fisheries. Under most circumstances, industrial forest mills require loggers to obtain BMP certification in order to market wood products. Ultimately, implementing and monitoring effectiveness of the Forestry BMP program helps to insure that water resources are adequately protected in logging and other forestry management activities. By practicing BMP stewardship, the public importance and benefits of managing forests to produce quality water to support beneficial uses such as aquatic habitat, recreational uses, as well as development and growth. Based on periodic monitoring, South Carolina has realized a high degree of BMP implementation, and the intent is to continue to use this program to limit the effects of silvicultural and harvesting practices on water quality. BMP design and implementation appears to be a better way to prevent water quality impacts and conserve associated resources than setting and enforcing outside rules and regulations that may not fit South Carolina or the timber industry circumstances.

►Since 1996, additional direction to monitor a wide variety of ground-disturbing and other activities with the potential to impact water quality has been developed. This direction includes the National BMPs (USDA Forest Service 2012), the BMPs previously mentioned. Consistency with BMP direction in the 1996 Forest plan was an important element. BMP compliance checks on Forest activities suggest that BMPs are being implemented and water quality is being sufficiently protected from ground disturbance (Adams and Hook 1993; Adams 1994, 1996; Jones 2000, 2005; Sabin 2006, 2009, 2012). However, with the poor delineation of streams and riparian areas, there remains some potential that projects may not always have all the information needed and must rely on field delineations and checking to be sure resources are adequately protected. Availability of LiDAR products has the potential to improve ability to identify streams, riparian areas, and ditches in project planning.

►Surface water, riparian, wetland, and groundwater connectivity was not discussed in the 1996 Forest plan. These connections are evident, but not well defined or understood as to what those implications may be to the Forest plan and management activities. However, we do know that certain activities such as groundwater removal, material borrow or mining, roads, and hydrologic modifications may have effects which need consideration within the Forest plan.

2.2.3.2 Direction in the 1996 Francis Marion Forest Plan

Chapter 3 in the 1996 Francis Marion Forest plan contains Forestwide standards designed to protect water quality from management activities, such as herbicide application, timber harvesting, and other ground-disturbing activities. This list is not all inclusive, but just a highlight of some relevant Forestwide standards:

> **FW-101** Avoid construction (roads, trails, recreational sites, etc.) in floodplains and wetlands whenever there is a practical alternative.

FW-102 Restore primary skid trails and log landings on soils with sandy loam to clay textures within 10 inches below soil surface (i.e., smooth out and fertilize primary skid trails and fertilize log landings) to minimize loss of soil productivity and water quality as needed.

FW-103 Install adequate road drainage structures to provide for normal surface water movement.

FW-104 Fertilize sites according to guidelines specified in the Forest Fertilization and Soil Productivity Improvement Guide (on file in the planning records in the Forest Supervisor's Office in Columbia, South Carolina).

FW-105 Locate skid trails, log landings, and log ramps on wet sites and riparian areas according to the following criteria, and only as designated by a Forest officer.

a) Locate permanent log landings on elevated terrain generally at 0.5-mile intervals.

b) Limit concentrated skid trails and log landings to no more than 10 percent of an area so that compaction and other disturbance will be contained to only those areas disturbed.

c) Construct log ramps on the best drained sites to facilitate access to log landings from system roads and to minimize skidding distance.

d) The number of log landings will be the minimum needed to harvest any area.

FW-106 Prevent and minimize the effects of soil compaction, rutting, and puddling during activities through the use of low ground pressure equipment, aerial systems, activity suspension or other soil protection measures as mats, bridges, woody fill, etc., when saturated or wet soil conditions cannot be avoided. Indicators that may signal caution include: (1) the water table within 18 inches of the surface; (2) difficulty in walking across the site without compacting, seeing or hearing surface or groundwaters under foot; (3) presences of wetland indicator plant species, hydric soils and/or saturated or flooded hydrologic conditions during activity; and (4) events which flood or saturate soils.

FW-107 Avoid direct application of fertilizer to water bodies including streams (unless prescribed for wildlife habitat improvement).

FW-109 (R8–VM) In each project, water quality is protected from nonpoint-source pollution through use of preventive "best management practices" (BMPs). Implementation of BMPs, monitoring and evaluation of their application and effectiveness, and adjustment of practices as needed are done to protect beneficial water uses and comply with State water quality laws. BMPs are applied to all activities. In each project, site-specific conditions must be assessed, and the BMP's needed to meet state water quality standards must be employed.

FW-115 Maintain a near continuous (unbroken) canopy of vegetation for 30 feet on both sides of perennial streams and water bodies. Resource management activities may be implemented if riparian conditions are maintained or improved and the natural supply of large woody debris into the streams and water bodies is not impaired. Timber harvest methods that ensure a residual basal area of 50 percent can be utilized when managing a zone from 40 to 70 feet on perennial streams and water bodies and 40 feet on either side of intermittent streams. Use of mechanical equipment will be limited to protect the riparian and water resources. Additional zones adjacent to riparian areas and ephemeral streams can be established as necessary to meet site specific conditions and management objectives. The width of the zones will depend on slope, vegetation and soil conditions. These zones will be

managed to protect soil and water resources by the types of management activities in these zones and controlling the use of equipment.

Although more recent than the 1996 Forest plan, the Southern Region Guide for Soil and Water Conservation Practices is also consulted as needed in the attempt to apply the combination of practices that protect water quality and limit effects (McLaughlin et al. 2002).

Desired future conditions identified in the Forest plan did identify the need for streams, ponds, wetlands, and riparian areas of the Forest reflect healthy, functioning ecosystems. However, due to limited information at that time, the primary assumption was that implementing BMPs and Forest Standards would be sufficient to do this. As a result, there was no specific or special measures identified in the objectives to improve conditions.

2.2.3.3 Introduction

Water resources are an important aspect of National Forest conservation and management. All life has some water dependency from the very basic cell makeup, providing moisture to maintain complex plant and animal needs, or to scenic beauty and water-based sports. Sedell et al. (2000) provide an excellent oversight document for “Water and the Forest Service”, discussing its various aspects and importance of water to the Forest Service mission.

With the oversight and approval of Environmental Protection Agency (EPA), the South Carolina Department of Health and Environmental Quality (DEHC) address and regulate water resources within their authority. DHEC is responsible for setting guidance and regulations to ensure South Carolina’s surface, ground, and drinking water resources meet State water quality standards. DHEC's website has numerous water quality related reports, documents, maps, links to regulations, peer-reviewed literature, and brochures. The South Carolina Forestry Commission has been authorized to oversee the development, implementation, and monitoring of practical measures that avoid, limit or mitigation the effects of forestry activities as described in the SC Forestry Best Management Practices (BMPs) Manual. More about Best Management Practices will be discussed later.

In addition, other resource agencies and nonprofit organizations such as SC Department of Natural Resources (DNR), Army Corps of Engineers (ACOE), U.S. Fish and Wildlife Service (USFWS), Natural Resources Conservation Service (NRCS),U.S. Geologic Survey (USGS), SC DHEC, Coastal Council, SC Coastal Conservation League, National Oceanic and Atmospheric Agency (NOAA), Clemson University, University of SC, College of Charleston, City of Charleston, Charleston and Berkeley counties and others have collected information, conducted studies, and evaluated conditions relative to many coastal water and environmental topics.

The USDA Forest Service Southern Research Station (SRS) has been a leader in addressing many of the hydrological and other resources of southeastern forests. Within the Francis Marion, the Santee Experiment Station is directed by SRS, conducts forest- and hydrologic-based research, collaborates with many other agencies and technical peers, and contains the national hydrometeorological station conducting research on coastal ecosystems. Many of these studies are referenced in the content.

Another nearby coastal research center and collaborator with hydrological research is Belle Baruch-Hobcaw Barony, where cooperative research is conducted by Clemson University, University of South Carolina, and others. The USGS College of Charleston, ACOE, and others have been important SRS partners in the Turkey Creek and groundwater studies. Adjacent coastal states also have research and hydrological information that may apply to coastal

ecosystems of the Forest. North Carolina has collected substantial information and conducted analyses on hydrological conditions and many examples of minimizing, stabilizing or restoring modifications and land use alterations (Russell 2013). It would be extremely difficult to interject all of this information into forest planning and land management, and that is where some of the external peer review and agency collaboration helps insure that meaningful or critical information has not been overlooked in this process.

Beyond this, one may note the presence of historical information or references that provides added context to what is prepared. Substantial efforts to utilize Forest GIS and LiDAR information should be evident in this assessment.

2.2.3.4 Hydrologic setting

Reference condition is an interesting, but often unappreciated topic with respect watershed, hydrological, and aquatic conditions. Conditions were substantially different before the nonnative human influences that began about 500 years ago. This period of time is contained within the Little or mini-Ice Age, which was a more humid, cooler period about 150 to 650 years ago, with internal colder or warmer weather cycles during this period of time (Kemp et al. 2011; SCDNR 2013). Sea levels were about 2 feet lower. Beaver were abundant in the pre-Columbian era, but were trapped out by the 1700s (Logan 1859). This period was before roads, dams, dikes, railroads, drainage ditches, stream channelization, rural and urban development, air pollution from burning coal, etc. These modifications directly or indirectly helped drain or fill wetlands, control flooding, limit tidal influence, and modify, straighten and/or enlarge channels to "improve drainage" (SC Regulations, 1911-1962, Berkeley County et al. 1963; Trettin et al. 2008). Early history may have less runoff, more flooding, greater hydroperiods, more wetlands, higher evaporation, increased hydration of floodplains, and increased stream permanence (Schumm et al. 1984).

The result would be a wetter landscape, perhaps with increased bottomland and wetland forests. Primary disturbance regimes under reference conditions are natural variability in intensity, frequency, and disturbance from fire, flooding, and severe wind. The low gradient characteristic of most of the topography, the stream morphology, was most likely sinuous stream types such as Rosgen DA (braided-anastomosed) and Rosgen E types (Rosgen 1996) (see "Stream and Aquatic Extent, Types and Classification [Rosgen]" subsection under "2.2.3.5 Existing Condition and Information" for more information on Rosgen stream classification). The low gradient channels were further stabilized with vegetation types adapted to saturation and flooding with extensive rooting density that provided highly resilient and stable stream channels. The presence of Rosgen G (gully) type may be found on higher gradient stream sections characterized by entrenchment into the sand-dominated materials of the coastal landscape.

2.2.3.5 Existing Condition and Information

Note: This section includes hydrologic cycle rainfall, evapotranspiration, water flows, deep seepage, and associated background history.

Current conditions indicate an average water balance for the SC coastal plain of 50 inches of rainfall, 30 inches of transpiration, 10 inches of evaporation and 10 inches of runoff, with a minor part lost to deep seepage, perhaps 1 inch. These are general approximations that may vary with the land use and conditions, as well with year-to-year rainfall variation. Many of the coastal watershed boundaries are not well defined, adding some uncertainty and error to reported amounts. Some of the past studies have been reanalyzing with improved spatial detail such as LiDAR based DEMs (Amatya et al. 2012, 2013). Substantial annual variability in rainfall exists

from about 30 inches in a very dry year to as compared to accounting for 80 inches in a very wet year, ultimately affecting the other components (Amatya et al. 2008). The examples of Turkey Creek near Huger (USGS gaging station, drainage area 22.7 square miles) (see Figure 2-21) indicate a flatwoods watershed that may take 12 hours to peak after intense rainfall and 10 to 15 days to return to flow prior to the rainfall event. Coastal watersheds are slower to respond than areas with steeper terrain. Turkey Creek has both ditching and straightening that promotes drainage and dikes that may delay or prevent it.

However, time of year can also make a big difference. The growing season pulls the water table down faster through transpiration, so the hydrologic response may be lessened and delayed as water is absorbed and ground water levels decline. Some vegetation may use more water than others, and this depends to some degree on the availability of water in the soil, extent of root system, and ability for the species to conserve water by regulating the opening and closing of the stomata. Pine can use substantially more water than hardwoods or grasses as their stomata remain open or at least do not shut down as tight during dry conditions, so they tend to use more water (Swank et al. 1988).

In hydrologic modeling of the southeastern U.S., Sun et al. (2005) found that reducing transpiration rate estimates for upland hardwoods as beneficial to their water balance modeling efforts for watersheds containing USGS stream gauging stations to be consistent with water yield. Dr. Tom Williams, retired Clemson hydrologist from Belle Baruch, has indicated that this effect may be lessened where water is highly available in the coastal plain, as bottomland hardwoods may use as much water as pine in those circumstances. Too much water, such as in wetlands that remain flooded or saturated well into the growing season, develop anaerobic conditions that may slow some plant processes and water uses unless they have special adaptations to increase oxygen or perhaps root support (e.g., aerenchyma in some vegetation, advantageous rooting like cypress knees for support). In persistent flooded conditions evaporation may increase while transpiration is reduced. Whether pine or hardwood, extensive regeneration of forests will temporarily reduce transpiration and increase site moisture conditions until the forest is reestablished. With the heavier dependence on thinning and leaving residual stands for regeneration, specialized woodland or savanna habitats, the increase in site moisture after operations is probably less of an issue than when clearcutting was common.

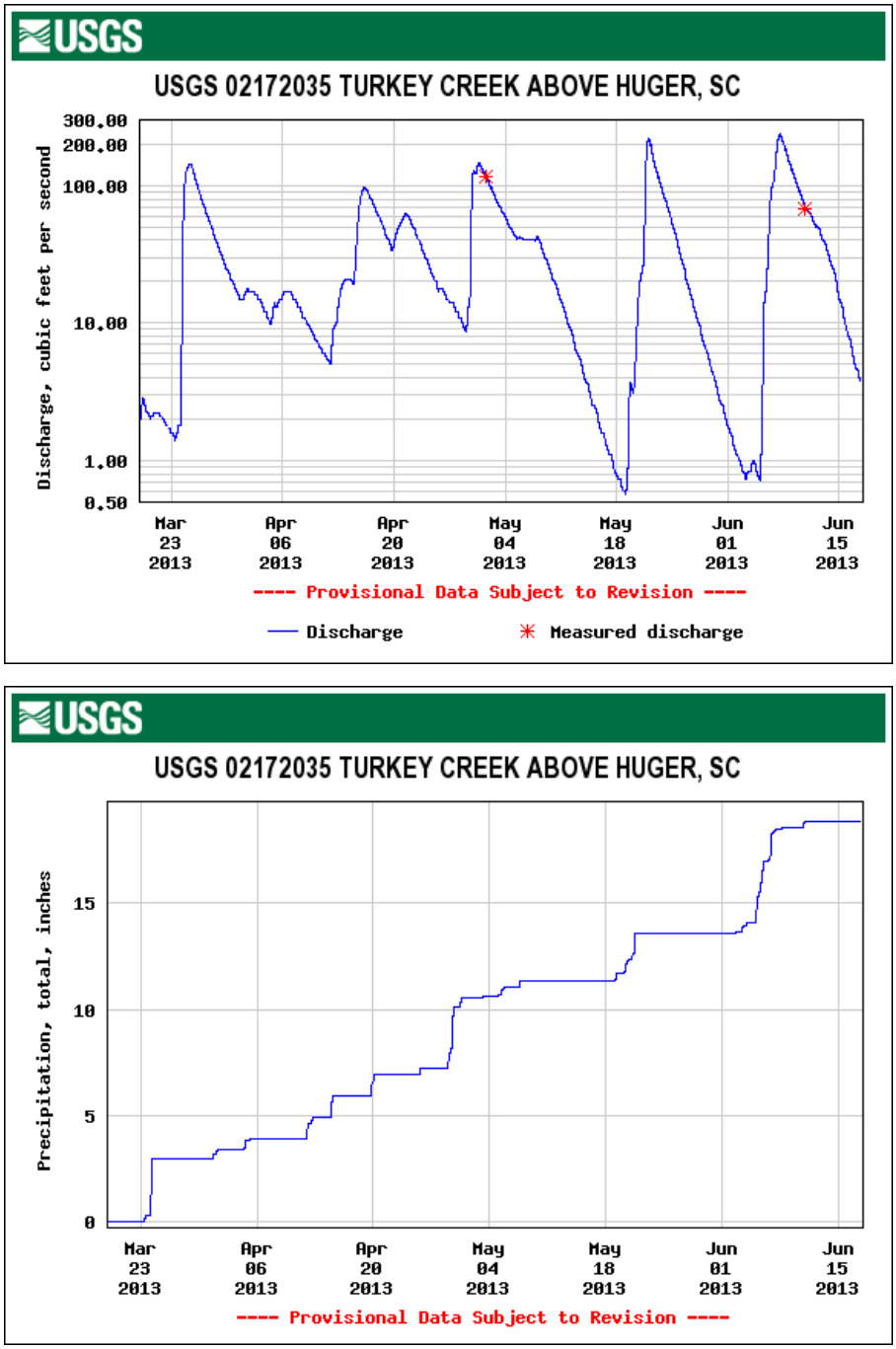


Figure 2-21. USGS graphs for precipitation and discharge for Turkey Creek

Hydrologic Modifications

Note: This section discusses dams, canals, ditches, roads, trams, bedding, and dikes, etc.

Hydrologic modification practices were common in early America (SC Regulations, 1911, 1920 to 1962; Happ 1945; Berkeley County et al. 1963; Trimble 1974; Schumm et al. 1984; Trettin et al. 2008). Many early land uses applied some degree of hydrologic modification to streams, riparian areas, and wetlands ranging from temporary to relatively permanent changes. Few restoration efforts have been used to reverse these hydrologic changes. Continuing efforts to

modify hydrology were encouraged by the State legislature and counties into the early 1970s (SC Regulations, 1911, 1920 to 1962; Berkeley County et al. 1963). The general perception was that "swamps" were impediments to access and contained foul water. Substantial efforts to drain the swamps to improve access (roads and rails), agriculture, pine forestry, range, wildlife, development and industry were heavily supported. Nationwide, wetland ecosystems suffered substantial losses.

By the 1980s, the conversion of wetlands on the National Forests had ceased in response to the Executive Order 11990 on wetland conservation signed by President Carter in 1977 and the directives in the Clean Water Act administered by the Environmental Protection Agency, states and Corps of Engineers. Some adjacent landowners during this early regulation period had continued to look for opportunities and took to more inventive ways to modify wetlands, in some instances influencing the Forest. With the heavy vegetation cover, hiding activities from aerial inspection was still fairly easy.

Relative to the 1985 plan, some minor drainage activities such as localized site bedding or mounding of soil with the Brache scarifier for individual pine tree planting sites continued, but the trend for their use was constrained to on-site modifications, and avoiding connectivity to the stream system in order to avoid water quality and potential drainage implications. These minor modifications were well within the regulations that allowed some normal silvicultural and agricultural activities to be exempted. Even though some minor modifications continued on the Forest, the intent to change wetlands to uplands was strictly maintained. Some of the useful equipment like the Brache scarifier almost disappeared from use on the Forest prior to 1996. By the 1996 plan, drainage modifications were not maintained, but in most instances, were never actively decommissioned or removed. Many of these ditches became plugged by debris from Hurricane Hugo and the lack of salvage operations in wet areas or bottomland channels. However, ditches along roads or connected to stream crossings were evaluated to see if debris removal was needed to prevent road flooding and provide passage of water at culverts and bridges. Nonetheless, the 1996 plan continued to have a provision that would allow bedding, piling, and other minor site modifications that would promote or maintain pine over hardwoods or other vegetation.

All subwatersheds with portions of the Francis Marion National Forest currently have numerous hydrologic modifications from roads, dikes, ditches, road crossings, stream straightening, and in some instances, site drainage or severe rutting. Modifications are extensive, with a partial survey of noticeable dikes and stream crossings (does not include canals and ditches) averaging 100 modifications per subwatershed. Most of these are localized, and their current level of effects difficult to determine (Hansen et al. 2013). However, most do not appear to be temporary structures and will continue to influence hydrologic function to varying degrees by restricting drainage (Trettin et al. 2008; Amatya et al. 2013). Apparent on the landscape due to the availability of LiDAR DEMs are ditches, stream channel straightening, dikes and small dams.

In analyzing the road imprint information, an assumption was made that road ditching was not used to help drain the land. But we know that there are instances where roads were constructed in the past to not only provide access, but contribute to land drainage. In other circumstances roads had inadequate or insufficient culvert cross drainage, and sometimes impounded water on one side of the road to the detriment of reduced flow to wetlands on the other side. Lands diked such as rice culture or constrain tidal influence probably had the intent to limit or retain surface water for extended periods of time. Developers probably selected areas to flood that already showed signs of being able to hold and retain water, such as wetlands, and they just wanted to

increase or manage the hydroperiod such as to increase the ability to control competing vegetation by flooding or to provide water during dry conditions by storing water. They may have converted some salt to freshwater marshlands, as they would be easier to burn off, rather than clear. Most of the intentional ditching and significant hydrological modifications were stopped prior to the 1985 plan. Ongoing permits for ditch and drainage maintenance are in place with Berkeley and Charleston counties and SC Department of Transportation, but no other information is known about the specifics at this time (Amy Fore, Francis Marion National Forest 2013).

Altered hydraulic conductivity and depth-to-water table were among the effects of skidding logs where ruts occurred due to timber salvage after Hurricane Hugo (Aust et al. 1993). They found that on low gradient land, the upper side of the ditch and the rut would be much wetter, and the lower side would be drier, indicating that the rut was affecting the natural movement of water across the land. The 1996 plan, the SC BMPs, and timber sale contracts address the need to prevent excessive rutting. Firelines or fuel breaks locally may modify hydrology as these were either cut into the surface, or eventually degrade into the surface after repeated use, altering movement of surface or subsurface water patterns. Fire plows were once the standard practice, but they tend to entrench more quickly into the landscape, causing more permanent hydrological impacts and are generally not used as much today, or mitigated by site smoothing following prescribed burn treatment or wildfire. Bladed firelines are more common today and they still can modify hydrology, especially when repeatedly reused, but the modifications can generally be reduced with smoothing and/or installing features that limit excessive capture and transfer of concentrated water to offsite areas. Most practices that were once standard procedures have been evaluated, and measures taken to reduce their level of effect by altering the practice or timing of work.

Some modifications seem insignificant, such as ruts; however, most ruts and especially deep ruts do not recover on their own and exist for extended periods of time. They influence the natural flow pattern of surface and subsurface water, extent and function of aquatic, riparian and/or wetland ecosystems (Aust et al. 1993; Hansen and Law 1987).

In 1985 and 1996 plans, most of the past hydrologic modifications were not as well-known as to their extent and location, and were not identified as something to be improved on the National Forest unless something we caused that needed mitigation. Efforts were made to avoid converting wetlands to uplands, and limitations were put in the plans to avoid site drainage and rutting impacts even beyond what would normally be allowed. In most instances, the conversion to pine was favored where it could be reasonably accommodated and it is not unusual for wet areas converted or restored to pine to reduce the water table from increased transpiration.

Certain hydrologic modifications for wildlife and waterfowl activities were developed many decades ago in attempts to provide hunting opportunities as well as replace some of the lost habitat. Currently, dikes developed for the greentree reservoirs to improve coastal waterbird habitat are being managed and maintained. These developments have been maintained when damaged and continue to provide the desired hunting and habitat benefits. More details on these areas are provided under section 8.6.1.3 “Current Conditions and Trends.”

Most of the past site ditching, canals, trams, dikes for rice culture, agriculture, wetland and riparian area drainage, straightened and channelized streams are not currently being maintained. A few adjacent to private lands have long-standing special use permits or agreements for their long-term maintenance to control flooding or other needs on private lands. Modifications associated with roads are being reduced by installing bridges or improved culverts when it is

evident they are modifying flow, constraining aquatic passage, or have lost their functional capacity from sediment, debris, or beaver. Continued road maintenance of stream crossing structures are needed to maintain road safety, limit road damage from flooding, and provide aquatic passage. Road ditches and cross-drain culverts are being maintained as needed to keep them functional and where possible, limit the extent of modification. Culverts are cleaned when sediment, debris, or other issues are identified during normal or storm-related maintenance. When road flooding or adjacent site flooding problems are found, the conditions would be earmarked and installation of properly designed cross drainage would normally be planned. The Forest transportation analysis plan (TAP) has some potential to identify road segments no longer needed that may result in decommissioning sections.

There have not been major efforts to evaluate effects, costs, benefits, or needs to remove or reduce the effects of hydrologic modifications. However, it is likely that many of these may need complex project analysis, specific to the situation.

Stream and Aquatic Extent, Types and Classification (Rosgen)

Much of the hydrology was affected by the coastal geology, with a series of alluvial marine terraces, primarily sandy deposits that consist of barriers or dune-like structures, beaches, and general landform that follow South Carolina coastal form. The oceans that once expanded to the fall line contracted and expanded during various periods of geologic time left a series of relatively flat marine terrace terrain. The riverine system is eroded into these marine terraces, and in doing so, becomes the lower parts of the terrain, where surface and shallow groundwater is likely to flow or be intercepted by these depressions in the relatively low gradient landscape. In general, these long, linear, marine depositional features contain flow patterns that often align with the coastal features. Large rivers such as the Santee River have had sufficient energy and momentum to break through the pattern of coastal features, flowing more directly to the ocean. Smaller tributaries have developed their own channel networks within the major geologic coastal patterns. Stream types within the Rosgen classification system most common to low to very low gradient channels include DA (braided, anastomosed, with floodplain), E (sinuous pattern, with unrestricted access to floodplain), and G (gully type channels commonly in steeper terrain or where affected by canals, stream straightening or ditching, with limited access to floodplain). Although dendritic stream patterns are common, trellis forms are found were linear coastal erosion wear lines are evident in the LiDAR shaded relief. Channel gradients have been affected by numerous in-channel structures as well as the coastal geologic patterns. Areas with more gradient tend to be more defined channels; areas with low gradients are often sinuous and/or braided, with less definition to channel form. In the headwaters and some larger depression areas, the demarcation between what is a stream and what is a wetland may not be recognizable. The litmus test may be during major storms: Does the water flow off or reside on the landscape for extended periods? However, considering the riparian linear depressions within the marine terrace landforms, there should be little surprise that with few exceptions, riparian areas also have hydric soils characteristic of wetlands.

Return of the beaver, although the species is not abundant, suggests that they have locations or conditions that they may have once preferred. The periodic droughts would contribute to their relocation. As the adjacent riparian vegetation is often flooded or consumed by their actions, the beaver move into other areas of opportunity. Sometimes road culverts become an easy target or an unavoidable opportunity for the beavers to plug up flow and feast on the adjacent vegetation. Some stream sections flow freely with relatively low, but uniform gradients, while others pass through surface depressions that must fill after dry periods before flow can be passed.

Under some circumstances channel entrenchment or ditching may increase the connectivity with groundwater (water table) which could contribute to flow permanence. However, typically the channel modifications in the sand-dominated coastal areas and probably most other areas are apt to help drain the adjacent water table, reduce flow permanence, and thereby reduce connectivity as stormflow removal is favored over groundwater replenishment with these practices. The extent of flow permanence has not been fully determined, and varies substantially. Efforts have been made to improve the estimate of flow permanence or nearly permanent (i.e., perennial and intermittent streams) by using preliminary information collected by the NC DENR in the North Carolina flatwoods and rolling coastal plain as provided by Periann Russell (2013). With some uncertainty and high degree of data variability from the North Carolina data, it suggests that on average, 27 to 38 acres is typically sufficient to produce an intermittent or perennial stream. Although there would be substantial risk is applying this data to project planning without more ground truthing, this information is useful at a planning level to help estimate stream extent and drainage density. Preliminary riparian and ecological classifications also used this information to estimate the extent of the headwater influence (Hansen et al. 2013; Simon and Heyden 2013). The current stream coverage in the National Hydrographic Database (NHD) and watershed boundaries in the Watershed Boundary Database (WBD) are administered by the U.S. Geologic Survey and considered official, but inadequate for making many of the estimates needed in forest or project planning. Contacts have been made to officially present updates that will lead to approved changes in these coverages before plan analysis and completion.

Added information on flow permanence may be inferred from the GIS intersection of stream channels with the USFWS wetland maps and mapping of hydric soils with water tables near the surface. Stream channel maps are in the process of being improved by using LiDAR shaded relief, DEMs, and flow accumulation models. Several models and attempts are underway to improve the location and estimated extent of the channel network (Hansen et al. 2013; Simon and Heyden 2013). Andy Maceyka of the Forest GIS staff has been instrumental in the LiDAR analyses including stream modeling and digitizing stream and many ditch locations. A substantial amount of work is needed to provide relatively clean path for flow accumulation modeling coverages. Without the cleared hydrologic path from interuptions, theflow accumulation models tend to get diverted and loose channel contact (i.e., run straight) in the flat terrain. Amatya, Panda, and others have also been using this technology on the research watersheds at the Santee Experimental Forest to improve stream and watershed boundary coverages with similar results in improving stream network and watershed boundaries (Amatya et al. 2012, 2013).

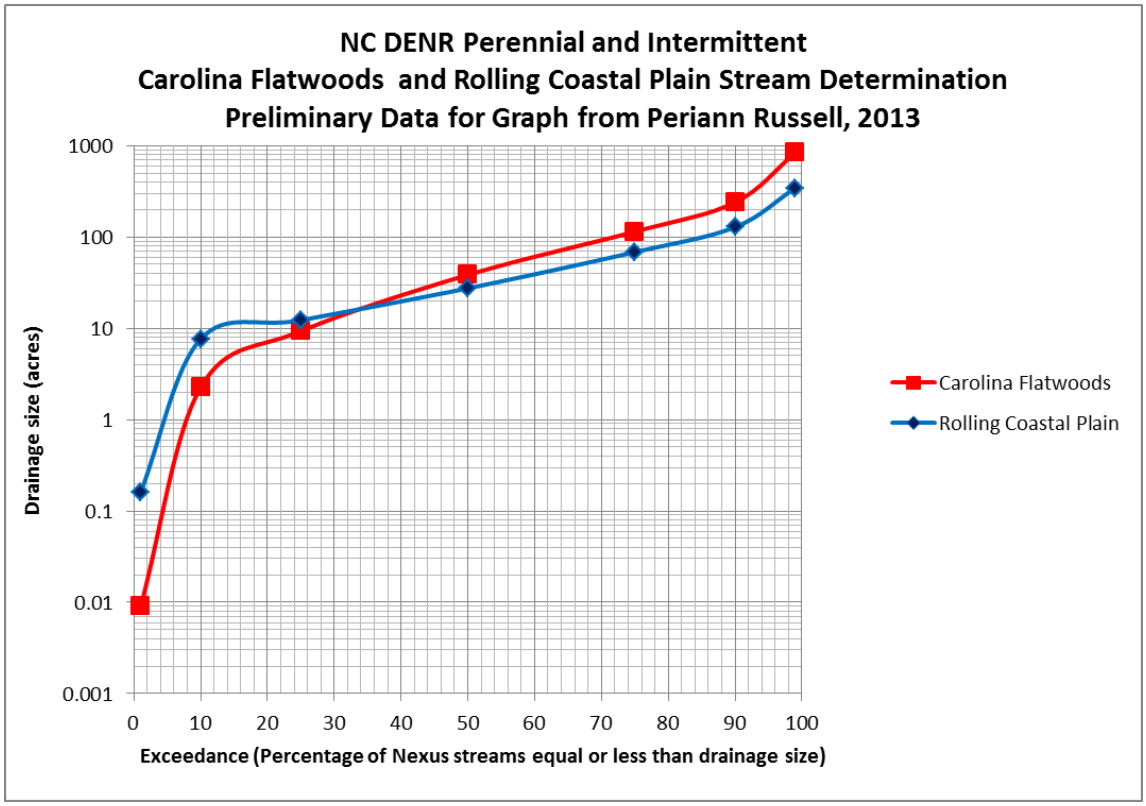


Figure 2-22. Drainage size and exceedance percentage indicates the frequency of intermittent or perennial streams in North Carolina sampling to identify source waters within the Carolina Flatwoods and Rolling Coastal Plain

Source: Plotted from Russell, 2013 data.

Ephemeral streams produce stormflow infrequently in response to effective rainfall events, typically do not have well defined channels, and are not normally in connection with groundwater conditions (i.e., near the water table). That said, we really do not know on a landscape scale where uplands or wetlands end and ephemeral, and intermittent or perennial streams begin. There are remote indicators we look for, but field verification is needed. In some instances, isolated or headwater wetlands and swamps may have ephemeral linear pathways that connect into the recognizable streams, but we do not have the information to differentiate them as either swamp or poorly defined, ephemeral channel, for in some instances, they may be both. If we get 12 inches of rainfall in a tropical storm or hurricane, and depressions fill up and overflow or flow in recognized pathways, are they not then functioning as an ephemeral channel. Also, the ditching for drainage of wetlands complicates these considerations. Substantial areas of the Forest have hydric soils with close groundwater connectivity, so ephemeral streams will often flow into areas with hydric soils, and then do they stay ephemeral, or with the increased groundwater connectivity become intermittent or perennial. When a defined channel emerges, that may be the source point we can recognize, but leaf and needle fall can easily obscure flow passages which may be temporarily noticeable only following significant storm events. If all ephemeral flow channels or pathways were to be identified, looking for flow indicators after a major stormflow event is the most reliable and difficult. They may be found during drier periods by persistent looking for areas where organic debris has moved, sometimes in a sinuous, discontinuous path. Indicators do not always reside on the landscape to be noticed for extended periods. Presently, we assume that portions of ephemeral streams may be within the riparian

areas or wetlands, and thus may have more than brief groundwater connectivity. However, we recognize that we are limited in our ability to detect them.

Figure 2-22 indicates a high degree of variability in flatwoods and rolling coastal plain acreage before a defined or Nexus stream begins with recognizable characteristics (Russell 2013). Of all the physiographic areas, the flatwoods is the most variable in the area needed before recognizable streams develop. That is not surprising when applied to the Forest, when we consider the primary geologic landforms include several marine terraces, with some large relatively flat as well as depression surfaces, variable rates and depths of erosion as well as deposits from the riverine, estuarine and marine systems, and some karst interactions and surface connectivity. Factor in the Santee River, one of the larger rivers to enter the Atlantic Ocean within the United States, with notable historic water and sediment loads that helped modify substantial portions of this coastal landscape. Not all the perennial and intermittent channels are well defined in the coastal plain, but LiDAR, infrared photos and flow modeling tools are helpful in estimating their extent.

Connectivity with groundwater resources and floodplains is more common with perennial and intermittent streams. Even though many of the streams have some degree of channelization or straightening, they typically have access to their cfloodplain, except in a few places where there is more gradient and significant entrenchment from flood prevention channelization, gully entrenchment, and development has limited the channel's access to the floodplain. It is evident that in these coastal systems, with shallow water tables, the connectivity between streams and groundwater may be more obvious than normal. Unusual in sloping terrain common to the piedmont and mountains, but in analysis, it became evident that the riparian areas on the Forest in most cases have hydric soils and are also wetlands. This coincidence may in part be a result of the humid, semitropical, well distributed rainfall in coastal areas, but also may be due to the past erosion into relatively flat marine terraces, as the resultant depressions in the relatively flat landscape being fed by subsurface flow and shallow groundwater. In more rolling, hilly or mountainous terrain, the slope of the terrain tends to move rainfall as runoff or shallow interflow more quickly across the slope or to stream channels. Extensive areas with shallow water tables are not dominate in sloping terrain, as they would leak, seep, or form springs that flow to channels due to the topography and erosive materials. Hillslopes do contribute water to floodplains and riparian bottomlands and sometimes wetlands, but not in the same way that the relatively flat marine terraces would. However, during severe drought, groundwater connectivity and streamflow in many perennial streams can be temporarily lost or at least go under the streambed (hyporheic flow) and perhaps continue to some degree in the valleybed or confined subsurface substrates.

More information on groundwater condition and connectivity is provided in the groundwater section that follows.

Freshwater and Marine/Tidal Influences

Although the entire area has been affected by the ocean and tidal influence during earlier geological periods, current extent of freshwater and marine tidal influences are generally fairly well defined, but also modified by hydrologic modifications in the past (Logan 1859; Kemp et al. 2011; Berkeley County et al. 1963; Doar 2013). Expected climate changes could increase tidal influences due to sea-level rise, affecting perhaps 2 percent of the Forest over the next 50 to 100 years (Figure 2-23). There is generally no accurate line of demarcation, as the tidal influence is not static, and can vary with the intensity of the moon (full and new), storms, wind

speed/direction and other factors. Storm severity, also a byproduct of climate change, could also influence the extent of tidal action.

Some of the earliest modifications to the landscape were to provide access to streams and tidal channels for food and other needs. Eventually, roads and trains were constructed to increase access to the city and ports for trade and sale of goods, and these activities were often on uplands. In some instances, taking the shortest route may have resulted in wetlands and streams being filled, and some bridges and culverts added to limit distances or expense. Rice culture used dikes to control the extent and hydroperiod of saltwater and freshwater influence. The dikes acquired at Tibwin Plantation are a significant hydrologic modification that has added critical habitat to the Forest. Their function provide an example of measures used in the past to limit or control the amount of saltwater in favor of fresh or brackish water management for coastal freshwater or brackish habitats for migratory waterfowl.

The largest hydrologic influence to the area is the Santee and Cooper River modifications associated with the dams, diversion, and rediversion connected to the Lake Marion (Wilson) and Moultrie (Jeffries) dams, diversion, and rediversion (St. Stevens). Besides creating relatively shallow lakes, the ultimate diversion of water from the Santee River system to the Cooper River system is linked to the Charleston development, generation of power, and harbor transport.

In reference condition, the Santee River had sufficient baseflow to provide freshwater to the ocean. However, the resultant dams and diversion heavily reduced flows in the Santee River during baseflows (The Nature Conservancy 2005), which allowed salt water entry well beyond the Santee Delta, influencing water quality to Jamestown, South Carolina (Nixon 2004). The extent of this impact is variable with the flow in the Santee River and the height of the tides. Tributary areas such as Wambaw Creek and Echaw Creek, once freshwater, are also affected by periodic salt excursions, especially during low Santee River flow periods with high tides, high wind, or hurricane periods that can push tidal flooding or storm surges further inland (Hansen 2008). We note that there are also other dams within the Santee River Basin that probably affect flows that first reach Lake Marion. The diversion to Lake Moultrie and Cooper River and rediversion back through the St. Stevens Dam accommodate both the need to divert flow into the Cooper River System for water quality and navigational needs related to Charleston Harbor and Port, and as well provide a means to return sediment-laden flow back into the Santee River.

Bill Hansen, Forest hydrologist, and Jeanne Riley, fisheries biologist, were involved with some of the initial FERC relicensing efforts for the Santee Cooper Project, and this involvement resulted in some increased attention on the Forest to monitor for salt water influence within Wambaw Creek that helped to increase the awareness of these issues (Hansen 2007). Publications by The Nature Conservancy and the U.S .Geological Survey have also identified Santee River effects from salinity to water quality and aquatic vegetation. Continued efforts with FERC, Santee Cooper, and Corps of Engineers in relicensing efforts suggest that there may be increased attention to and opportunity to increase instream flows during critical low flow periods, which could reduce or mitigate effects of salt water influence on the lower Santee River and tributary areas.

The Atlantic Ocean Intercoastal Waterway was developed as a safer navigational canal that borders much of the Atlantic coast including portions of the east side of the Francis Marion. Awendaw Creek and Tibwin Creek have direct AIWW connections and Wando River has indirect connection through the Cooper River. All receive tidal influences and areas with tidal marsh dominated by *Spartina*, *Juncus*, or other species. Many of the tidal waters have a few access points where canoes or small boats can be used. Some of these are natural, but most were

constructed for access to tidal waters. The Forest also maintains access to various waters including:

- the motor boat ramp access to the Intercoastal Waterway at Buck Hall,
- canoe access into lower Awendaw Creek,
- small boat access into Wambaw Creek,
- kayak access to Chicken Creek area along the Santee River,
- Santee River ramp access at McConnells Landing,
- recreation facilities at Echaw Creek and Guilliard Lake,
- pond and wetland boardwalk at Seewee Visitor Center,
- Seewee Shell Mound boardwalk and boat landing at Huger Campground.

Groundwater

Surfacial groundwater resources on the Francis Marion have linkages with surface waters and most if not all of the riparian, wetland, and aquatic ecosystems. However, the extent and importance of these linkages are poorly defined, and applicability to this plan will be considered, but unknown at this time. However, some research has been able to differentiate between the extent that rainfall and surface and subsurface waters contribute to streamflow (e.g., Vulava et al. 2008). Substantially more is known about shallow groundwater or surficial groundwater, as well as various subsurface aquifers than can be presented here. Figure 2-23 and Figure 2-24 (copied from Konikow (2013) suggest there has been a lot of groundwater use in the past that contributes to the decline in elevation of water levels within aquifers, with perhaps some apparent reductions as mentioned in section 8.6.1.3 "Current Conditions and Trends." Declines in water levels near Florence, South Carolina, a substantial distance from the Forest near the fall line suggest 50 to 150 foot drop in groundwater levels over the last 15 to 60 years, depending on location. In general, groundwater depletion since 1900 in coastal South Carolina has steadily increased with time, but there appears to be a leveling off of some of the increased uses. The water use information provided in section 8.6.1.3 suggests that most of the groundwater community uses have been converted to surface water uses.

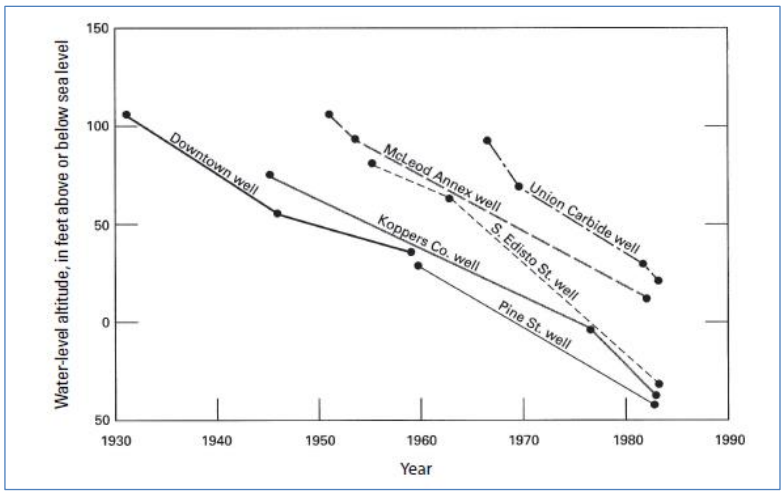


Figure 2-23. Water level declines for selected wells in the Middendorf Aquifer near Florence, South Carolina

Source: From Aucott (1996) as modified from Aucott and Speiran (1985); figure from SLAMM Model provided by TACCIMO (2013).

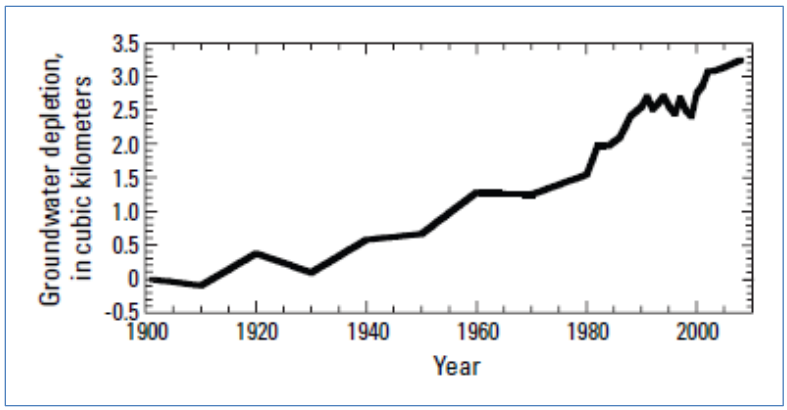


Figure 2-24. Cumulative groundwater depletion in the Coastal Plain Aquifer System of South Carolina, 1900–2008

In general, the subsurface aquifers deepen from the fall line to the ocean and from the north to the south along the coast. Surficial aquifers have similar tendencies and more variability because they are influenced by both surface erosion and variability in marine terrace deposition and erosion. This information will be considered, but the influence on Forest planning is not obvious. Groundwater stream interactions and recharge have been addressed to varying degrees by various studies, including several recently within the Turkey Creek Subwatershed of the Forest (Vulava et al. 2008; Callahan 2010; Callahan et al. 2011; Garrett et al. 2011). Various research works by Dr. Tom Williams (Clemson, Belle Baruch) and Devendra Amatya, Carl Trettin, and other researchers at the Santee Experiment Station are also probably applicable to the groundwater topic for the vicinity. Further interactions may be needed to refine this discussion as well as address to what level this information may have application to the Forest plan and management activities.

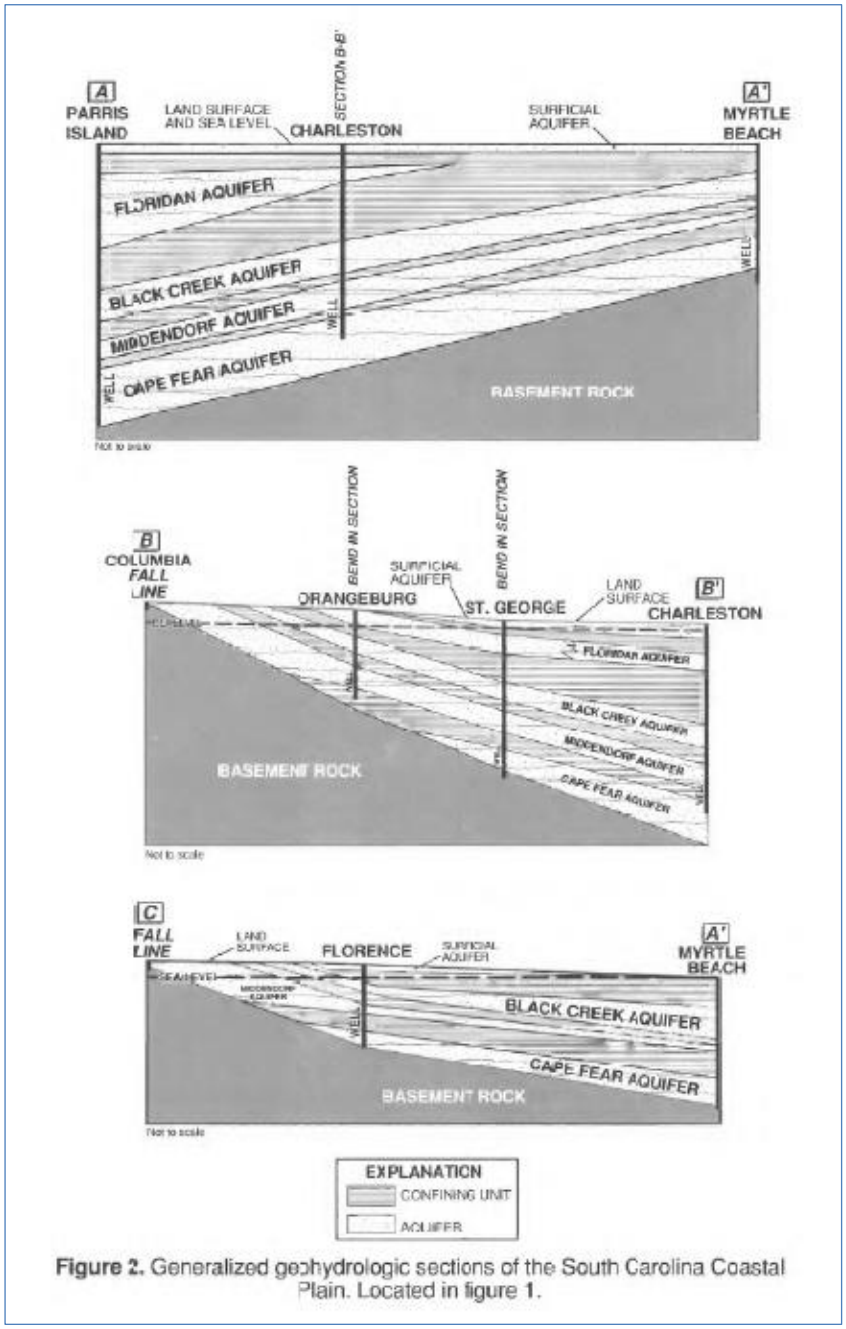


Figure 2-25. Generalized geohydrologic sections of the South Carolina Coastal Plain

Note: Example of the generalized vertical and horizontal groundwater aquifers from the South Carolina fall line to ocean and along ocean front from Parris Island to Myrtle Beach, with Charleston, South Carolina marked. Figure from Cambell and Heeswijk (1996).

2.2.3.6 Stresses and Threats to the Reference Water Resource Condition

With the significant difference between the reference water resource condition prior to major influences of man and the present status of the landscape with the remnants of many hydrologic modifications that have altered surface hydrology, it would be difficult to say that surface water resources could be any more stressed. Many of the coastal streams on the Forest are essentially dry during drought periods. The climate change with more severe floods, winds, and drought could add some additional stresses and threats to the streams and aquatic resources as well as the those within the tidal interface. However, it would be hard to imagine anything much worse than the direct hit of Hurricane Hugo to the Forest in 1989. Expanding urbanization, population, and associated water needs and demand, could materialize into additional stress/threat issues. Some of the past actions that have resulted in threats and stresses could be addressed, reversed, or restored to help offset their impacts in the future. Groundwater threats seem to have dissipated because most communities and municipalities have moved to treating surface water sources for their needs. However, continued attention may be needed on this issue. There are influences outside of the national forest that contribute stresses or threats. The activity of mining in the Dutart Creek vicinity has not shown up as significant ground water use reportable to SC DHEC as perhaps it is under the 3 million gallon monthly use criteria for reporting. Nonetheless, groundwater uses in karst areas found nearby is a concern relative to land subsidence and accelerating sink hole development. Groundwater contributes to and drives many of the riparian and wetland ecosystems, so there is concern when nearby activities contribute to the water table that has been effected by past activity. There is substantial data on groundwater collected by the Santee Experiment Station, College of Charleston, Clemson University at Belle Baruch that could be brought in relative to the soil types present and site conditions. Most of the data is either of short duration, or long duration without detail. The intent of some of this groundwater data collection was to help show the link between the shallow groundwater and surface water stream gauges. Efforts to model various aspects of the hydrologic cycle of coastal systems attempt to link components such as soil types, rainfall, surface and ground water, stream flow, water quality and land uses are underway at the Santee Experiment Forest with associate collaborators, contributors and researchers with other agencies and institutions. The LiDAR data has helped to increase awareness of the extent of the past and various ongoing changes in contributing to the stresses and threats to water resources as many things were not considered in the 1996 plan.

2.2.4 Water Quality

Water quality is an important aspect of the watershed condition issues already addressed. One assumption that needs to be challenged is that the blackwaters common to the Francis Marion are noted for poor water quality. The tannins that tint the water are from the high level of organic materials contained in wetlands. Due to the slow breakdown of organic materials in wetlands, some nutrients needed for abundant aquatic life may be low or limited, such as sodium, calcium, potassium, magnesium, bicarbonate, and phosphorus so those species present are able to adapt and function under the conditions. The high acidity from organic acids also increases the solubility of aluminum, a negative for many aquatic species. The main surface water quality regulations in South Carolina, in response to the CWA directives, include R. 61-68 Water Classifications and Standards and R. 61-69 Classified Waters (SC DHEC 2012a, 2012b). R. 61-68 Water Classifications and Standards set forth the classifications of South Carolina waters and establishes water quality standards to protect and maintain the existing and classified uses. R. 61-69 Classified Waters compiles the waters of the State by name, county, classification and any designation and a brief description of any site-specific numeric criteria that apply. Reports are prepared every couple of years in SC DHEC 303(d)/305(b) reports, and are the most recent and

best source of water quality information we have (SC DHEC 2012c, 2012d). The 303d report identified impaired waters based on a network of water quality monitoring stations across the State, and it identifies impaired waters for various water quality attributes or conditions, some of which are linked to aquatic life indicators. The 305b report describes the State's water quality programs and gives the analysis, status, progress, and conditions of the State's waters.

Section 303(d) List

For waters that have pollutant impairments (i.e., those waters that are listed on the CWA Section 303(d) list), the following are listed stream segments in or near the Francis Marion.

The primary listings are fecal coliform that affect recreational uses or for shellfish gathering waters including Awendaw Creek, Guerin Creek, Wando River, Turkey Creek, Cane Gully Branch, Wadboo Swamp, and Echaw Creek (SC DHEC 2012). Listings for mercury include East Fork Cooper River near Quinby Creek, Wadboo Creek, Santee River below Wilson Dam, diversion and rediversion canals, and Wambaw Creek. The entire coastal marine and estuary areas have been identified as a water quality advisory for fish consumption issues (SC DHEC [map available]). Lakes Marion and Moultrie and well as other major streams are also included.

Table 2-21. Total mean daily load (TMDL) target dates that are to be addressed with implement plans to treat the water quality impairments by SC DHEC and affected parties

TMDL TARGET DATE	BASIN	HUC	DHEC STATION LOCATION COUNTY USE CAUSE
2025	SANTEE	30501120101	ST-532 SANTEE RIVER BELOW LAKE MARION (WILSONS) BERKELEY FISH HG
2025	SANTEE	30501120105	ST-031 REDIVERSION CANAL AT US 52 (SC-037A) BERKELEY FISH HG
2025	SANTEE	30501120106	ST-528 SANTEE RIVER @ US 52 (HWY 52 LANDING) WILLIAMSBURG FISH HG
2013	SANTEE	30501120205	RS-02467 ECHAW CK AT PITCH LANDING FRANCIS MARION NATL FOREST BERKELEY REC FC
2025	SANTEE	30501120206	ST-001 SANTEE RVR AT SC 41/US 17A NE OF JAMESTOWN BERKELEY FISH HG
2025	SANTEE	30501120302	CSTL-112 WAMBAW CK AT EXTENSION OF S-10-857 (BRIDGE NEAR BOATLANDING) CHARLESTON FISH HG
2022	SANTEE	30501120303	ST-006 S SANTEE RVR AT US 17 CHARLESTON AL TURBIDITY
2025	SANTEE	30501120303	ST-006 S SANTEE RVR AT US 17 CHARLESTON FISH HG
2025	SANTEE	30502010101	CSTL-079 DIVERSION CANAL AT SC 45 12.6 MI W OF ST STEPHENS (SC-025) BERKELEY FISH HG
2025	SANTEE	30502010101	CSTL-080 LAKE MOULTRIE @ DAM BERKELEY FISH HG
2022	SANTEE	30502010101	RL-02454 LAKE MOULTRIE SW IN OPEN WATER BERKELEY AL NH3N
2014	SANTEE	30502010201	RS-02461 WADBOO SWAMP AT S-08-447 THIRD BRIDGE FROM WEST BERKELEY REC FC
2023	SANTEE	30502010201	ST-007 WALKER SW AT US 52 2.5 MI S ST STEPHENS BERKELEY AL DO
2025	SANTEE	30502010203	CSTL-113 WADBOO SWP AT SC 402 BERKELEY FISH HG
2014	SANTEE	30502010203	RS-03333 CANE GULLEY BRANCH AT S-08-97 6.1 MI NE OF MONCKS CORNER BERKELEY REC FC
2014	SANTEE	30502010301	RS-02483 TURKEY CK AT FOREST SERVICE RD 251 IRISHTOWN FM SC 402 BERKELEY REC FC
2025	SANTEE	30502010304	CSTL-564 EAST FORK OF COOPER RIVER NEAR QUINBYCR BERKELEY FISH HG
2020	SANTEE	30502010401	09B-04 WANDO RIVER AT DEEP CREEK CHARLESTON SHELLFISH FC
2020	SANTEE	30502010401	09B-05 WANDO RIVER OPPOSITE BIG PARADISE ISLAND CHARLESTON SHELLFISH FC
2020	SANTEE	30502010401	09B-06 WANDO RIVER AT PARADISE BOAT LANDING CHARLESTON SHELLFISH FC
2020	SANTEE	30502010401	09B-09 DEEP CREEK - 1 MILE FROM CONFLUENCE WITH WANDO RIVER CHARLESTON SHELLFISH FC
2020	SANTEE	30502010401	09B-10 WANDO RIVER AT ALSTON CREEK CONFLUENCE CHARLESTON SHELLFISH FC
2020	SANTEE	30502010401	09B-12 GUERIN CREEK AT OLD HOUSE CREEK BERKELEY SHELLFISH FC
2020	SANTEE	30502010402	09B-15 WANDO RIVER AT NEW BRIDGE- ROUTE I-526 CHARLESTON SHELLFISH FC
2025	SANTEE	30502010701	CSTL-062 TAIL RACE CANAL AT US 52 & 17A BELOW LAKE MOULTRIE (SC-033) BERKELEY FISH HG
2017	SANTEE	30502090202	07-03 AWENDAW CREEK AT MARKER #57 CHARLESTON SHELLFISH FC
2017	SANTEE	30502090202	07-05 TIBWIN CREEK AT MARKER #42 CHARLESTON SHELLFISH FC
2016	SANTEE	30502090202	MD-268 AWENDAW CREEK AT MARKER #57 (07-03) CHARLESTON AL TURBIDITY
2022	SANTEE	30502090202	MD-796 AIWW TRIB NORTH OF SEWEE CAMP AND SOUTH OF HOUSES CHARLESTON REC FC
DATA FROM SC DHEC 2012 300D LISTING			
USE ABBREVIATIONS - REC - RECREATION, A L= AQUATIC LIFE			
CAUSE ABBREVIATIONS - HG = MERCURY, FC = FECAL COLIFORM, NH3N = AMMONIA NITROGEN, DO = DISSOLVED OXYGEN			

Typically these TMDL plans set waste load limits for polluters or activities as the primary means to affect change. Natural levels of pollutants such as fecal contamination may be considered as allowable background (SC DHEC 2012). Identifiable anthropogenic and other major contributing sources are typically identified for treatment. Elevated fecal coliform with many potential natural sources, including wildlife, make it difficult to address. Individual species can be major contributors, but this can vary, such as geese feeding on livestock forage lands were found to have high fecal contamination from giardia and cryptosporidium as compared to geese feeding from an urban reservoir (Graczyk 1996). Beaver are recovering into some of these

systems, and most warm blooded animals contribute to fecal pollutant loading (Tiedemann 2000; Nadareski 2000; Buckhouse 2000).

The impacts of wild hogs are a relatively new water quality concern. Feral hogs tend to concentrate into riparian areas where soil exposure, damage to riparian vegetation, and fecal pollutant delivery to streams is more likely. However, historic reports found by Danaher and Carlson on the Forest reported a total of 392 pigs and 150 cattle were removed from the Waterhorn in 1949, most of which were live trapped and returned to their owners. These were free-ranging pigs and livestock, which were common on the Francis Marion back in the 1940s. This would have been about 1 year after the Waterhorn was designated as a wildlife preserve (about 17,000 acres) via presidential proclamation and fenced. Impacts on water quality from pigs and cattle are therefore not necessarily new, but it has taken a long time to draw the connections between the two. Efforts are underway to reduce wild hogs by capture and removal, but it is unlikely the problem will be resolved any time soon. Urban expansion and population growth contribute additional fecal sources from septic systems, sewage, and wastewater transmission and treatment facilities, pets, and other sources. Storm periods are also apt to deliver excessive fecal loads that must be factored onto the calculations. Shellfish gathering waters are especially sensitive to the fecal contamination and the standard is set low to limit fecal pollution generated by land uses.

In the case of mercury, air born pollutants from coal burning and other sources have accumulated on the land. The conversion of mercury to methyl mercury in wetlands and its bioaccumulation in fish make it a human consumption issue that is difficult to address beyond heeding the consumption advisories (Figure 2-26). The effects of mercury on the fish, water birds, and other fish-consuming organisms are a biological concern (http://en.wikipedia.org/wiki/Methylmercury, http://www.usgs.gov/themes/factsheet/146-00/#wildlife).

Most of the effective dates for the mercury TMDLs will address the identified coastal waters by 2023 to 2025. Efforts to reduce the mercury pollutants will probably be aimed at the emissions from coal burning plants with expected decline in pollutant levels. Although not specifically listed, most blackwater systems dominated by wetlands either have the potential for mercury concerns as wetlands use sulfate reduction to change ionic mercury to methyl mercury (MeHg). Krabbenhoft (USGS) and others have shown that various aquatic organisms, such as mosquito fish, are able to assimilate the toxic mercury as an intermediate step as it accumulates through the food chain and concentrates in certain carnivorous fish such as bowfin and bass. Mercury problems are common in the wetland-dominated, blackwater portions of the Southeast and Northeast.

Although not listed as water quality impairments on the 303d listing, past major hydrologic modification of the Santee River has altered flow in the river, resulting in the reduction of instream flow during baseflow periods. This has allowed irregular fluctuations in tidal salt to brackish water to Jamestown, South Carolina, and also within the lower Santee River tributary channels such as Wambaw and Echaw Creeks. Salt water is heavier that freshwater, so it is sometimes referred to as a wedge as it moves upstream, with salt water on the bottom and freshwater on top. It has also become apparent that some of the low elevation channel structures of the past may have been installed to reduce tidal influence (Berkeley County et al. 1963).

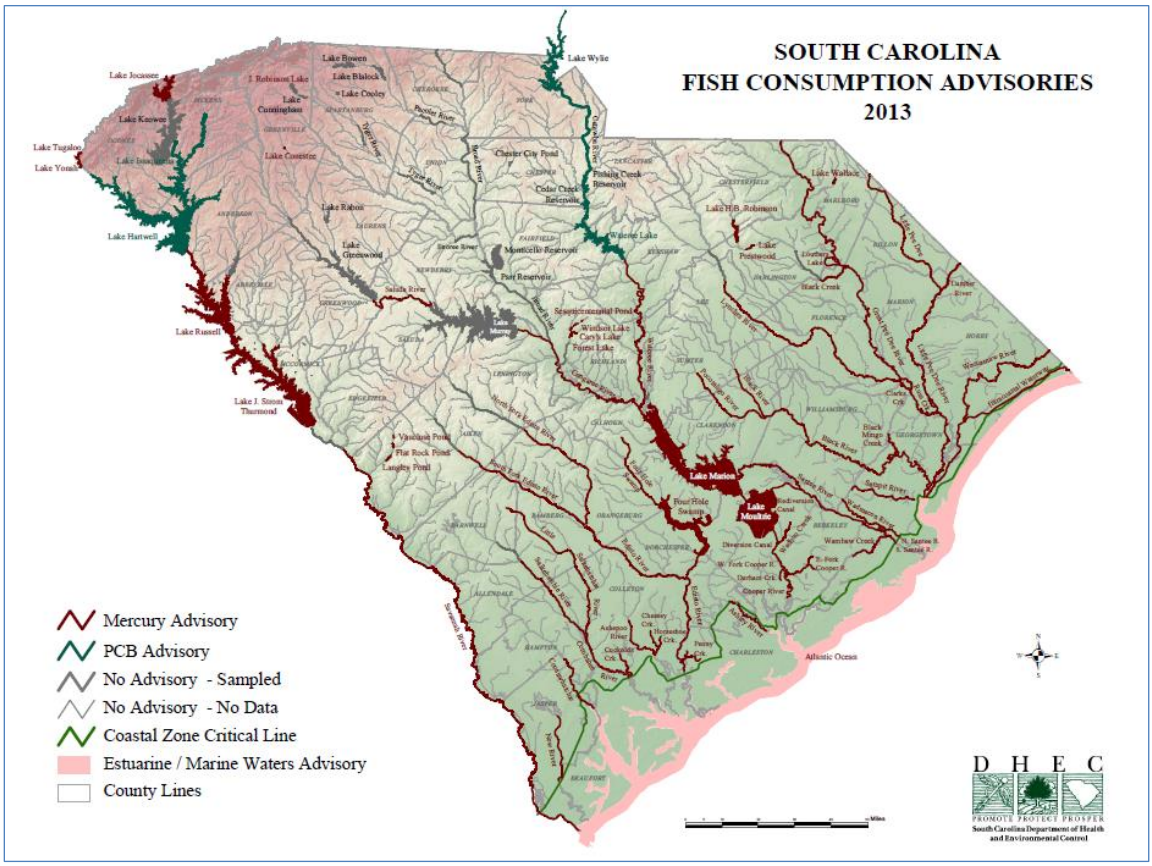


Figure 2-26. Fish consumption advisories for South Carolina in 2013

In the Cooper River system, where low flows are augmented by diversion of freshwater from the Santee River system through Lake Marion and Moultrie for water quality and navigation improvements, salt and brackish water influences may have been locally reduced. Rediversion of some of the flow back into the Santee River system was done to reduce sediment loading into Cooper River that had necessitated increased dredging and channel maintenance. It is not fully known the extent of the effects that numerous other hydrologic modifications to both drain and impound the stream systems have had to water quality and quantity, aquatic, riparian, wetland and terrestrial habitats. However, the Santee Cooper modifications are under consideration in the FERC relicensing, and the needs to increase baseflow into the Santee River were brought up in the analysis.

Climate change discussed elsewhere suggests that over the 50-year planning horizon, as much as 4 percent of the Forest could face some level of change in habitat due to sea-level rise, based on the SLAMM model information provided by TACCIMO. Tidal influence to lower elevation streams is expected to increase. Most of the change would move upland undeveloped land into scrub/shrub transitional marsh. There are limits to the data and a lot of assumptions made in these calculations. There is uncertainty with the climate change effects on streams, and even more uncertainty as to what they will do to water quality. Climate change is another stress/threat that would need to be considered.

TMDLs for turbidity and other water quality components may be identified periodically and included in the 303d report. There have only been a few past turbidity/sediment problem areas associated primarily with new roads and bridge fill containment and a bank failure into

Awendaw Creek at the end of Rosa Green Road. There are local impacts related to ATV use near or in streams and wetlands. Some turbidity can be "natural" in coastal waters due to the combination of freshwater storms and tidal diurnal fluctuations that tend to promote the development of entrenched bare channels, often with some protection from the *Spartina* and other species in the salt marsh. The heavy emphasis of channelization and stream straightening in some areas may have increased sediment sources from raw banks and the undermining of trees and rotational failures that contribute sediment.

Small, community housing development and varying degrees of urbanizing within the outskirts of the Francis Marion include activities that have potential to impact water quality. Subwatersheds with more agriculture, urban, roads, utilities and other development are more apt to have increased erosion and sediments, fecal, and other concerns. The State monitors many of the coastal areas due to their sensitivity and importance to the economy and public uses.

Water quality has been addressed in South Carolina by the State and forest industry for many years. Silvicultural guidelines were the precursors to best management practices (BMPs) (South Carolina Forestry Association 1976) followed with Best Management Practices for South Carolina's Forest Wetlands (South Carolina Forestry Association 1989). The Forestry BMPs set by South Carolina Forestry Commission is in many ways similar to how other states address and maintain water quality and associated resources by altering forest management practices to help minimize or mitigate activity effects (South Carolina Forestry Commission 1994, 2004). Reports relative to compliance and implementation of South Carolina Forestry BMPs highlight the long term success of this program (Adams and Hook 1993; Adams 1994, 1996; Jones 2000, 2005; Sabin 2006, 2009, 2012). Other land use activities also must follow measures to limit water quality effects to be consistent with the Clean Water Act and the Coastal Zone Management Act. Some activities are regulated by the Corps of Engineers and DHEC to ensure water quality consistency with certain Clean Water Act and associated state regulations. Past Forest plans have listed the intent to be consistent with BMPs and other water quality directives (USDA Forest Service 1996, 2012) suggest that continued implementation and increased monitoring are needed, but no substantive changes are needed.

There are reasons for the successes of the Forestry BMP program in South Carolina. For many decades, South Carolina Forestry Association, South Carolina Forestry Commission (SCFC), South Carolina Forest Industry, and the Forest Service have been strong supporters of protection water quality through the use of BMPs rather than regulations to limit the effects of forest management activities on water quality. This emphasis has extended through revising and the publishing of the forestry BMP manual as needed, logger certification, and mill support to take only logs from sites where BMPs have been used. As mentioned, monitoring of and reporting on the compliance, implementation, and effectiveness of BMPs have shown positive results. The Forest is a component of the SCFC BMP monitoring effort and has encouraged BMP compliance checks from SCFC.

Similar practices to BMPs and the national USDA Forest Service direction more specific to the Southeast can be found in the Region 8 Guide for Soil and Water Conservation Practices and in the Coastal Zone Management Act mitigation measures (McLaughlin et al. 2002). Certain activities also mentioned that affect perennial and intermittent streams (waters of the U.S.) are also regulated by the Corps of Engineers (COE) under the Clean Water Act, some requiring a permit. The Rivers and Harbors Act affects activities such as dredging and filling within navigable fresh, tidal, and connected waters including wetlands, and these regulations and

permitting are handled by the COE. For some activities, stormwater permits or water quality consistency determinations are needed by SC DHEC for certain ground-disturbing activities.

Hurricane Hugo had heavily damaged much of the Forest in 1989, and in some instances specialized BMPs were developed to avoid water quality and associated site effects during most of the salvage operations. Fortunately most of the operations were on drier sites, but with the transpiration reduction due to trees down, even these areas become wet. Wetland logging continued during infrequent dry periods, but efforts were made to concentrate roads to reduce widespread disturbances, limit rutting with low ground-pressure vehicles and timing equipment entry for favorable ground conditions. Several types of salvage logging were tried including horse skidding; high lead cable; helicopter; and various types of wide tire, duel tire, and low pressure crawler skidders. Road construction required limits that would avoid, minimize, or mitigate impacts to wetlands. Much debris remained in place and contributed to fuel hazards until it eventually decomposed or in some instances mulched or was abated with the installation of a fuel break or fireline. There were, however, infrequent instances of localized, deep rutting and soil puddling that occurred. At that time, the thought process was to try to minimize deep rutting by placing logging debris in the ruts and continue to use them, as it was preferred to limit damage designated areas as opposed to rutting up an entire area with dispersed skid trails. Review of emergency salvage plans and BMPs may be needed to ensure consistency with water quality protection and up-to-date with information technology.

Current trends for harvesting wetlands or wet conditions where rutting may occur are increased awareness to recognize soil type and the frequency and duration of wet periods, and include contract specifications that delay harvest until the ground is dry or operable enough to support equipment. Effective timing of activities has been shown to reduce effects. However, harvest delays on some areas may extend for months or years, so efficiency is reduced. Also, time delays may reduce the quality of the salvaged hurricane-damaged timber. In this instance, the delays can limit the ability to sell the product and can result in an eventual fuel hazard if not salvaged. Areas with extensive storm damage or recent regeneration or vegetation clearing have marked reductions in transpiration, with increased standing water or saturation, runoff, and/or evaporation. These changes in the water balance are typically short term considerations for forest management activities, but could last to some degree for 5 to 10 years.

Sediment is typically addressed with forestry BMPs as one of the bi-products that can be connected to forest management. The current condition relative to estimated suspended sediment concentration for all current or known land uses over a decade for all the subwatersheds is presented in Figure 2-27. The concentrations are based on a sediment delivery ratio of 10 percent and an annual water yield of 10 inches. These values between 5 and 35 ppm are only estimates to indicate the relative differences in ground-disturbing activities within the subwatersheds. Figure 2-28 shows the estimated tons of sediment from the major ground-disturbing activities for each subwatershed for a decade, and gives a better idea of where the likely sediment sources are. Subwatersheds range in size from 10,000 to 40,000 acres, and these numbers were not adjusted for these differences. The values presented in Figure 2-28 are adjusted for the acreage differences. Coefficients used for these are based on the RUSLE and SCS estimates of erosion and the procedures used and associated references were summarized in Hansen et al. (1994). Geoff Holden, Forest GIS Coordinator, has automated this analysis for forest and project planning uses (Hansen et al. 2013). These estimates contain many assumptions and uncertainties, and are normally used to compare alternatives with varying degrees of ground-disturbing activities and ongoing land uses. They are rough estimates that include current and likely work for each decade insofar as could be estimated, but should not be

considered as verified or accurate values. In this instance, they are presented to approximate, display, and/or compare the relative differences in subwatersheds for estimated sediment concentration and estimated sediment production by major activity or land use.

2.2.4.1 Stresses and Threats to Water Quality

Compared to the reference water resource condition, there are numerous legacy and ongoing activities that can influence water quality. The general trend is probably increased growth and urbanization to this area, with associated stresses and threats to water quality from increased population, Forest users, and needs for sewage and waste disposal; more vehicle, truck, and container traffic which increases the chances for spills or accidents. Although we have more tools today than ever before to help evaluate, find, track, treat, mitigate and/or reduce water quality stresses and threats, the resources to address these concerns at the state and Federal levels are more constraining than any time in recent history. The TMDLs identified by the State to address many of the fecal and mercury concerns are encouraging, but it is difficult to say what that might mean relative to the Forest. Many of the coastal streams on the Forest are essentially dry during drought periods, so there are obvious water quality stresses that occur under those circumstances. The climate change projections with more severe floods, winds, drought, and sea-level changes will add some additional stresses and threats. Increasing water demands can also contribute to the water quality stress/threat issues.

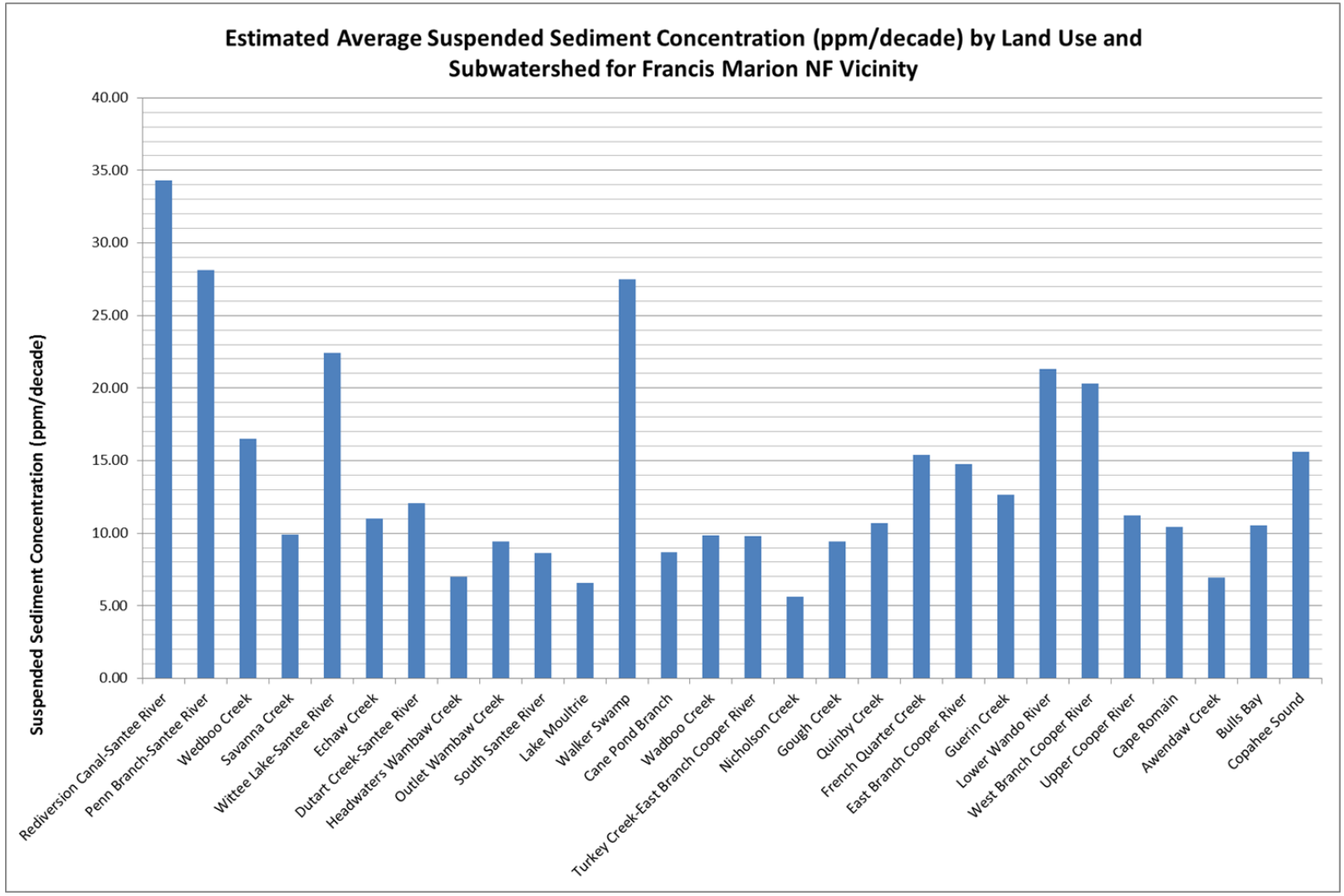


Figure 2-27. Estimated average suspended sediment concentration (ppm/decade) by land use and subwatershed for Francis Marion National Forest vicinity

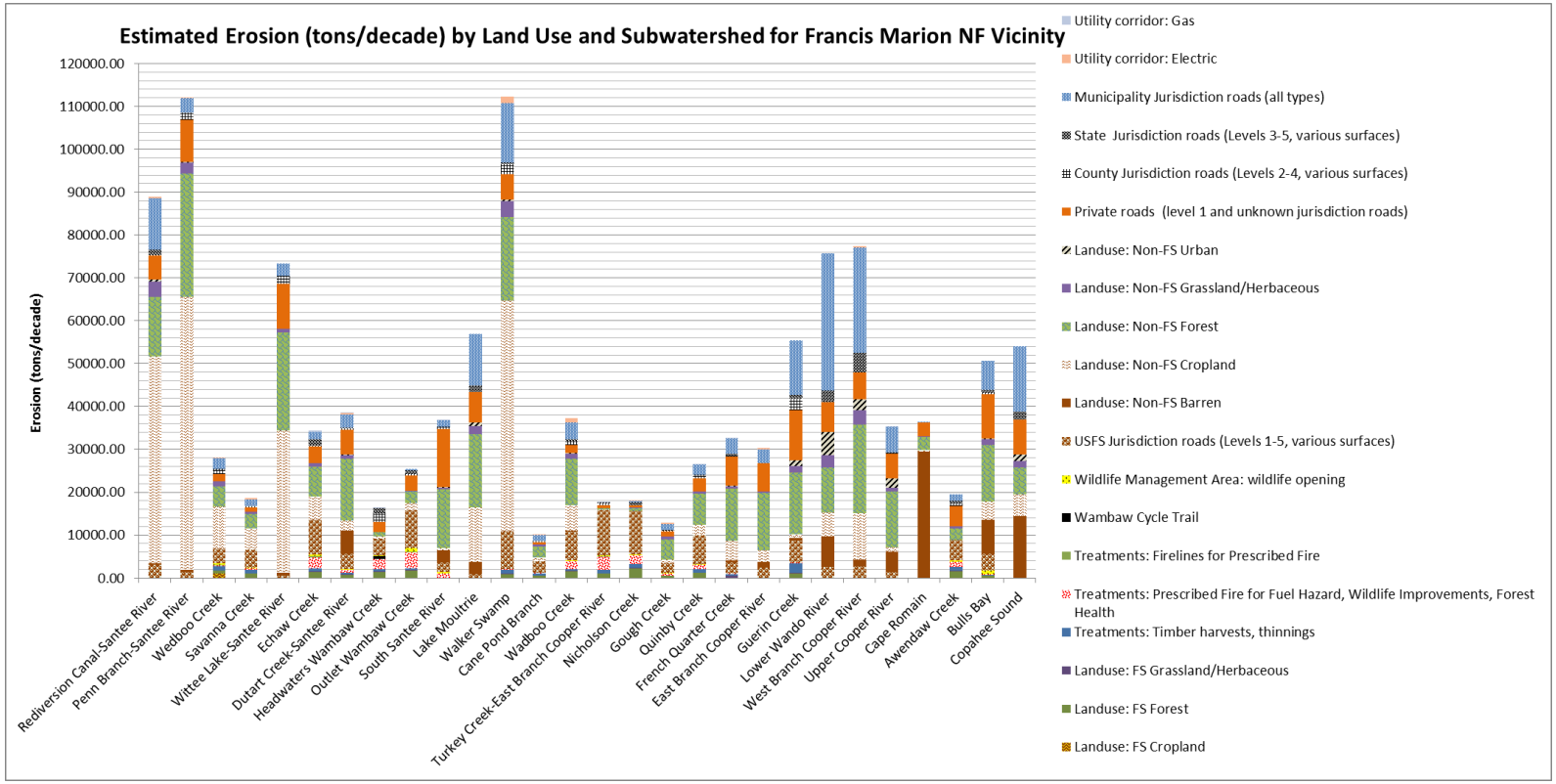


Figure 2-28. Estimated erosion (tons/decade) by land use and subwatershed for Francis Marion National Forest vicinity

2.2.5 Riparian Areas, Wetlands and Waters

2.2.5.1 Preliminary Findings

► Forest plans in 1985 and 1996 did not address the effects of hydrologic modification on the aquatic, riparian and wetland conditions. The extent of hydrologic modifications and the impacts to Forest resources and ecosystems were needed for agricultural production, access, pine management, and human habitation. Otherwise the land was typically considered unusable (Logan 1859; South Carolina Regulations 1911 through 1962). Hansen et al. (2013) in LiDAR analysis have found on average over 100 hydrologic modifications per subwatershed. Without direct evaluation, their degree of impact can only be estimated. The hydrologic reference condition for aquatic, riparian, and wetland systems has been substantially altered as past efforts to drain or control the movement and retention of water on the land occurred. Reference conditions would have supported a system with increased hydroperiod, resulting in more viable aquatic, riparian, and wetland systems for some resources.

►Currently, compensatory environmental mitigation for activities that modify streams, wetlands, and tidal lands or waters are in high demand. The 1985 and 1996 Forest plans did mention the desired conditions for properly functioning streams and associated ecosystems, but direction to restore hydrologic conditions from past activities was not an emphasis. Even when private operations and other public agencies are considered, there is likely to be insufficient mitigation banks or projects that could be available to serve as mitigation for highways, ports, and other public projects. New direction is needed to recognize, and if desired, provide a basis from which to limit or constrain wanted and unwanted proposals, as well as facilitate consideration, collaboration, agreements, and activities that support critical ecological services that offer mutual benefits to the National Forest and public or other entities.

►The 1996 Forest plan mentioned and gave an accurate estimate of wetland areas, but did not provide direction associated with the different types of wetland areas, such as Carolina bays, depression ponds, pocosins, riparian areas, or marshes. The plan included the need to conserve wetlands and apply BMPs as part of the desired future conditions, but did not suggest their connectivity to stream systems, address past modifications, or mention the need to monitor or track their condition, function, or status. Most wetlands were included within the suitable timber category. Further evaluation and separation may be needed for the Forest plan to address the various types, management, suitability, function, and possibly restoration potential if modified.

►Current information in the geographic information system (GIS) was used to estimate the extent of riparian areas, wetlands, stream, lake, and tidal margins. Overlap between wetlands, riparian areas, depressions, floodplains, tidal lands, and aquatic elements make clear divisions of elements difficult. Duel designations such as wetlands within riparian floodplains are not uncommon. In 1996, 143,000 acres of wetlands were identified. Currently, the estimate includes 153,000 acres, but this includes embedded streams, riparian, and wetland types. The primary need is to develop improved direction to compare reference, current, and desired conditions. The 2012 planning rule requires that revised Forest plans address management activities in riparian areas. Guidance may be needed for restoration of hydrology and other resources and also to help determine when existing conditions, with modifications, are acceptable.

►The extent of ephemeral streams is not known or easy to determine in the low-gradient terrain, where many streams are poorly defined or affected by past ditching efforts. Where found, ephemeral streams have some degree of protection with BMPs from limiting excessive ground disturbance, rutting, and crossing with equipment. There may be additional needs for guidance on their location and function, such as a field guide. However, there are no known current issues or direction to suggest a much greater focus is needed on these areas.

►The current stream coverage, based on the blue line streams found on the USGS topographic maps, underestimates the number of streams and stream locations need to be updated, particularly in the headwaters (Amatya et al. 2008, 2013; Hansen et al. 2013; Simon and Heyden 2013). Continued effort in evaluating the digital elevation models for the stream estimates will help improve watershed boundaries. Upgrading official coverages for streams and watershed boundaries is supported by USGS oversight and should be completed before the Forest plan revision. Many of the streams and watershed boundaries will be updated as improved data generated from LiDAR is incorporated into the GIS stream layer for the Francis Marion. Improvements will reduce uncertainties in Forest planning and analysis.

2.2.5.2 Direction in the 1996 Francis Marion Forest Plan

Riparian areas were not identified in the 1997 Forest plan, but chapter 3 in the 1996 Forest plan contains standards that protect riparian areas. This following list is not all inclusive, but a sample of some of the standards used:

> **FW-108 (R8–VM)** Consult with the Corps of Engineers, Coastal Council and Environmental Protection Agency as necessary for activities in wetland areas and along navigable streams to exchange information and acquire needed permits.
>
> **FW-109 (R8–VM)** In each project, water quality is protected from nonpoint-source pollution through use of preventive "best management practices" (BMP's). Implementation of BMP's, monitoring and evaluation of their application and effectiveness, and adjustment of practices as needed are done to protect beneficial water uses and comply with State water quality laws. BMP's are applied to all activities. In each project, site-specific conditions must be assessed, and the BMP's needed to meet state water quality standards must be employed.
>
> **FW-113 (R8–VM)** Aquifers and public water sources are identified and protected. The state is consulted to ensure compliance with their ground water protection strategies.
>
> **FW-115** Maintain a near continuous (unbroken) canopy of vegetation for 30 feet on both sides of perennial streams and water bodies. Resource management activities may be implemented if riparian conditions are maintained or improved and the natural supply of large woody debris into the streams and water bodies is not impaired.
>
> Timber harvest methods that ensure a residual basal area of 50 percent can be utilized when managing a zone from 40- 70 feet on perennial streams and water bodies and 40 feet on either side of intermittent streams. Use of mechanical equipment will be limited to protect the riparian and water resources. Additional zones adjacent to riparian areas and ephemeral streams can be established as necessary to meet site specific conditions and management objectives. The width of the zones will depend on slope, vegetation and soil conditions. These zones will be managed to protect soil and water resources by the types of management activities in these zones and controlling the use of equipment.

Ephemeral streams in the low-gradient flatwoods are difficult to identify, let alone evaluate their connectivity with surface waters, proximity to groundwater, or contribution to riparian areas or wetlands. The 1996 plan had direction to follow BMPs, which limit ground-disturbing effects to ephemeral channels in so far that water quality would be impacted. Unless there are other reasons to suggest otherwise, such as wetland or riparian indicators, ephemeral streams on the upland landscape would normally not be considered part of riparian areas or wetlands, would not have stream management zone or other special management beyond those practices described in the BMPs. If there are aquatic or riparian habitat needs pertaining to ephemeral channels or linear-flow depressions, they should be addressed in the aquatic section.

In 1985 and 1996 plans most Forest areas were suitable for timber production, including riparian areas, such as management area 29–Swamps and Swampy Flats, had 15,171 acres suitable for timber production and 5,644 acres unsuitable. Riparian areas and wetlands were for the most part considered manageable for timber production, if done properly. With the Sumter and other Southern Appalachian Assessment Forest Plans identifying the riparian corridor as unsuitable, a renewed look at suitability for timber management for consistency may be needed.

In the 1996 Forest plan, we recognized that about 50,000 acres of pine lands had hydric soils and would classify out as wetlands, since both loblolly and longleaf pine are considered facultative species that can be present in both upland and wetland ecosystems. It is uncertain how many of these lands were pond pine, a facultative wet pine species. Much of the mature pine lands were heavily impacted by Hurricane Hugo, so there was no push to constrain timber harvest or salvage residual areas by identifying all hydric soils (wetlands) as unsuitable for timber harvest. It was generally believed that Forest standards and guidelines, including BMPs, would limit the management effects to acceptable levels for riparian areas and wetlands. No substantial degree of monitoring has occurred to substantiate this. Issues identified with ATV trails and damage to wetlands has been mostly addressed, but recurrent impacts are expected from off-trail uses.

The 1996 plan included the desire to avoid converting wetlands to non-wetlands, but really lacked discussion on the various types of wetlands or the potential for wetland improvement or restoration. Continuation of practices to maintain former site modifications of wetlands were allowed in 1996, but were seldom used or needed. Some modified areas damaged by Hurricane Hugo and not salvaged or burned may have converted back to hardwood or wet savanna if burned. Burning in combination with drought may also favor establishment of these pine into some wetland areas. In 1985, fertilization with phosphorus was also used to favor pine establishment and growth in some wetland areas (McKee and Law 1985).

2.2.5.3 Definitions

Definitions of terminology from the 2012 planning rule used for this assessment:

> *Riparian Areas* ~ Three-dimensional ecotones (the transition zone between two adjoining communities) of interaction that include terrestrial and aquatic ecosystems that extend down into the groundwater, up above the canopy, outward across the floodplain, up the near-slopes that drain to the water, laterally into the terrestrial ecosystem, and along the water course at variable widths (36 CFR 219.19; see Appendix A for more information).
>
> *Riparian Management Zone* ~ Portions of a watershed where riparian-dependent resources receive primary emphasis, and for which plans include plan components to maintain or restore riparian functions and ecological functions (36 CFR 219.19: see Appendix A for more information).
>
> *Wetlands* ~ Those areas that are inundated by surface, or groundwater with a frequency sufficient to support, and under normal circumstances does, or would support, a prevalence of vegetation, or aquatic life that requires saturated, or seasonally saturated soil conditions for growth and reproduction. Wetlands generally include swamps, marshes, bogs, and similar areas (40 CFR 232.2) such as sloughs, potholes, springs, seeps, wet meadows, river overflows, mud flats and natural ponds (Executive Order 11990, "Environmental Laboratory," 1987; Mclaughlin et al. 2002).

2.2.5.4 Introduction

Riparian Areas. Initial efforts were made to differentiate riparian areas from wetlands, streams, lakes, and other aquatic habitats. However, there is overlap and there may be differences of opinion or

inconsistencies between hydrological and ecological classifications, and acres could be easily lost, double counted, or misrepresented. For this assessment, riparian areas may include some wetland and aquatic areas that overlap or cannot easily be differentiated. Riparian areas include areas that:

- Border perennial and intermittent streams, i.e., transition area between lotic (flowing) streams and uplands. This is the primary definition of riparian areas.
- Areas within the 100-year floodplain are included. These areas contain primarily hydric soils (wetlands) because they are eroded, linear depressions into relative flat marine terrace flatwoods within the humid semi-tropical climate, and the apparent tendency in this circumstance is to have shallow water tables.
- Unless differentiated, lotic (flowing) streams and channels are likely to be included.

However, under some circumstances, riparian areas may be combined for discussion purposes with isolated wetlands, aquatic, tidal, maritime, or other areas to make it easier or more efficient to address their overall presence on the landscape or their likelihood to be addressed similarly. Areas that may be considered along with riparian areas include:

- Isolated wetlands such as Carolina bays with no stream connectivity; adjacent upland areas along lotic (flowing) and lentic (non-flowing) waters with non-hydric soils (non-wetlands) if needed to protect water quality or aquatic habitat.
- Lentic water bodies such as lakes, ponds, and associated shore areas
- Springs, seeps, and other groundwater dependent ecosystems
- Areas within the 100-year ocean surgezone or floodzone of waterbodies.

In the initial estimates on the Forest, riparian areas include soils that flood or are linear depressions with hydrologic connectivity to freshwater, but some may also be tidally influenced. Riparian areas also typically qualify as wetlands. However, not all wetlands are riparian areas. As far as management, there could be reasons to single out some of the differences between lotic, flowing systems and lentic, non-flowing or static water systems. Some of the differences include energy, transfer of water, nutrients and sediment, habitat, and potential for flooding.

Riparian areas on the Francis Marion are typically dominated by bottomland hardwoods; hydrology includes rainfall, with often additional sources from flooding, shallow water table, or lateral interflow to help maintain them.

Riparian area estimates include bottomland hardwoods along streams, soils with flooding potential, and the 100-year floodplains along perennial and intermittent streams, including tidal channels that may have a mix of freshwater and brackish water. Also included in this estimate are hydric soils with linear depressions that have sufficient gradient to transfer flood or surface water during wet periods to streams. In the former planning regulations, the width of 100 feet along perennial and intermittent streams was considered the minimum or default width that will be evaluated as to their aquatic or riparian function, included in areas that have been modified. Regardless, the extent of riparian areas in 1996 was large coincident with the wetland estimates and it would have been difficult to separate the two. As mentioned, the estimate of wetlands in 1996 was 143,000 acres, and though not discussed in detail, a portion of this amount was riparian, and the default width of 100 feet presented did not apply to the acreage estimate. Approximately 39,000 acres of the Forest are classified as hydric soils that flood (i.e., mapped in the soils coverage as floodplains), and another 109,000 acres are hydric soils with linear depressions and appear to be connected hydrologically with stream systems (Table 2-22 and Table 2-23). However, the hydric soil linear depressions may have areas with poorly to no defined channels, and in some instances ditching was

used to increase drainage rate. That all of the 148,000 acres function as riparian areas along perennial or intermittent streams is probably an overstatement. However, the amount of riparian area is substantially more than mapped as floodplain. Whether these areas are riparian areas or hydrologically connected adjacent wetlands, there is a degree of protection, conservation, and modification of practices that are considered in their management. The 1985 and 1996 plans did not recognize the extent nor the hydrologic connectivity of the stream systems.

As shown, riparian areas, wetlands, and water-influenced areas on the Francis Marion National Forest are a dominating feature, and often a major part of the local landscape. The 1996 Forest plan recognized about 143,000 acres of wetlands (page 15 of 1996 Forest plan). There is some variability in the methods to estimate the extent of riparian areas, wetlands and deep water habitats, as they may include about 153,000 acres employing current analysis tools. The 1996 Forest Plan applied much of the overall direction found in BMPs, Coastal Zone Management Act, Executive Order 11990, but there was no real strategy in what specifically needed to be done to conserve, restore and manage these resources. Desired future conditions did support maintaining these areas as stable and functioning ecosystems, but details relative to how this would be accomplished, any emphasis on rectifying past alterations, maintaining or improving function, and monitoring or tracking were limited. In the descriptions of management areas, it was not that clear what might or should be done with the embedded riparian areas and wetlands to achieve the desired condition. There needs to be clear vision and direction in how these areas are protected, conserved, restored and managed for dependent resources.

Wetlands. There are a variety of wetland types, and levels of detail which can be used to describe them. Isolated wetlands have no identifiable connectivity to flowing streams or riparian areas such as Carolina bays. Tidal or brackish marsh is wetlands that may or may not also have freshwater stream or associated riparian areas connectivity. However, any tidal area is regularly connected to the ocean, and some tidal streams also have freshwater components. Lake or pond shore areas with hydric soils and vegetation that are not part of the flowing (lotic) channel system are wetlands when shallow, or considered deep water habitats when deep (Cowardin et al. 1979).

Wetlands which are isolated depressions embedded into upland areas do not have the same potential for flooding and flow energy typically associated with riparian areas. There may be some species that would occur in a more oxygenated or flowing water system as opposed to an anoxic condition typical of wetlands. If there is flow in wetlands, it may be more like sheet flow rather than concentrated flow paths within confined depression features or channels. The presence of ditching in some of these wetland depressions suggests an increased potential for connectivity to the stream system, and thus may function as a stream unless there are absolutely no indicators of function. However, the practice of ditching and draining wetlands for a variety of reasons in the past alters the hydroperiod and may provide access by predatory fish which are issues for some species.

Estimates of the extent of riparian areas and wetlands will almost always include some embedded waters that would include small- to medium-sized streams, seeps, springs and small ponds. See section 2.1 “Terrestrial Ecosystems, Aquatic Ecosystems, and Watersheds” for aquatic and terrestrial habitat discussions on the Francis Marion National Forest. In most instances, the larger streams and rivers, lakes, and ponds would be picked up in as water bodies in classification, but there is some overlap in the riparian areas, wetlands, and shallow shorelines and water bodies.

Approaches Used to Develop the Estimates of Riparian Areas. For the assessment, determining a final estimate of the different types and extent of aquatic, riparian areas, and wetlands has been difficult. Two approaches were considered (to some degree for an initial estimate), but the final estimate used a combination of the two approaches:

- The first approach used primarily hydric soil information provided by Jennings (2013) to be approximately 146,200 acres. This approach includes an estimate of the percent of hydric soils within all soil mapping units.
- The second approach used the 1st approximation ecological mapping by Simon and Heyden (2013) (see Table 2-22) estimating 148,300 acres. The 1st approximation of ecological classification gives an estimate of the different types and extent of wetlands, riparian areas, tidal marsh, and aquatic ecosystems (Simon and Heyden 2013). To some degree, the soils information was also used in developing the ecological classification. For discussion on the terrestrial ecological classification, see section 2.1 "Terrestrial Ecosystems, Aquatic Ecosystems, and Watersheds."
- The combined approach finally settled on using the soil series information where 95 percent or more of the soil mapping unit was hydric, but combined in the finer scale ecological wetland and pond elements that were outside of the hydric soil units and were not picked up in the soil mapping. This approach did not use the hydric soil percentage by soil series as used in the first approach. This combination approach was enabled with GIS analysis to estimate within the Forest boundary, which includes private lands, and another estimate for just Forest lands. This approach came up with an estimate of 153,100 acres (see Table 2-23).

The three approaches estimate the combined areas of riparian areas, wetlands, aquatic, and tidal influenced waters and marsh to be between 56 percent and 59 percent of the Francis Marion. Although there appears to be good agreement in the methods, all of the measures rely on soils to a substantial degree for these estimates.

Within the Forest boundary, including non-national forest lands, approximately 222,000 acres were estimated of the 417,000 acres to fall in the aquatic, riparian area and wetland categories (figures intentionally rounded). Of this amount, approximately 60,000 acres were recognized as typical floodplain wetland soils, 148,000 acres were linear wetland depressions with likely connectivity to streams, 6,000 acres of tidal wetland marsh, 1,600 acres water, and an additional 2,300 acres of isolated wetlands such as Carolina bays and depression ponds with no apparent direct connection to the streams, floodplains or linear depressions based on early ecological typing estimates (Simon and Heyden 2013; Hansen et al. 2013). These estimates did not include the flood surge zone along the Atlantic Ocean which flooded much of the land to U.S. Highway 17 in the Forest vicinity during Hurricane Hugo along the coast.

Table 2-22. Riparian area acreage as estimated by ecological classification on the Francis Marion National Forest

Ecological classification includes aquatic, wetland and riparian types on the Forest lands	Aquatic, Wetlands, Riparian Marsh Acres
Carolina Bay Wetland	3,264
Depression Pond (Sink Phase)	204
Depression Pond (Typic Phase)	1,311
Large River Floodplain Forest	3,710
Nonriverine Basin Swamp	2,483
Nonriverine Swamp and Wet Hardwood Forest	80,602
Peatland Pocosin and Canebrake (Carolina Bay Phase)	252
Peatland Pocosin and Canebrake (Typic Phase)	2,027
Salt and Brackish Tidal Marsh	2,568
Small Blackwater River Floodplain Forest and Blackwater Stream Floodplain Forest	11,374
Streamhead Seepage Swamp, Pocosin, and Baygall	76
Tidal Wooded Swamp	5,177
Water	55
Wet Pine Savanna and Flatwoods (Wet Phase)	35,219
Grand Total	148,322

Note: First approximation estimate (Simon and Heyden 2013). Due to different methods, slight differences with soil based estimate (Hansen et al. 2013).

Table 2-23. Comparison of two approaches used to estimate riparian areas, wetlands and aquatic areas

Comparison of Ecological and Soil Indicators Relative to Estimating Extent of Riparian Areas, Wetlands and Waters	Column Labels based on soils							
Row Labels based on 1st approximation ecological classification	Depression	Floodplain	Marsh	Water	non-riparian	Grand Total		total aquatic, wl, riparian, marsh
Altered Land	45	0			33	77		45
Carolina Bay Wetland	1426	1166		1	671	3264		3254
Depression Pond (Sink Phase)	37	15		1	151	204		204
Depression Pond (Typic Phase)	473	286		17	555	1331		1311
Dry and Dry-Mesic Oak Forest	16	74		0	794	885		90
Large River Floodplain Forest	1	3523		62	122	3710		3710
Maritime Forest	70	38	44	1	263	416		153
Mesic Slope Forest	6	134		0	73	214		140
Nonriverine Basin Swamp	2475				8	2483		2483
Nonriverine Swamp and Wet Hardwood Forest	56715	23851	36	0	0	80602		80602
Peatland Pocosin and Canebrake (Carolina Bay Phase)		248			4	252		252
Peatland Pocosin and Canebrake (Typic Phase)	952	1070			6	2027		2027
Salt and Brackish Tidal Marsh	93	64	2197	179	34	2568		2568
Small Blackwater River Floodplain Forest _and_Blackwater Stream Floodplain Fores	5942	4676	0	21	736	11374		11374
Streamhead Seepage Swamp, Pocosin and Baygall	9	57			10	76		76
Tidal Wooded Swamp	1135	3712	4	136	190	5177		5177
Upland Longleaf Pine Woodland (Dry to Dry-Mesic Phase)	0	0		0	7943	7944		
Upland Longleaf Pine Woodland (Dry-Mesic to Mesic Phase)	1	1		0	37382	37384		
Upland Longleaf Pine Woodland (Xeric to Dry Phase)	0	1		0	8527	8528		
Water		0		55		55		55
Wet Pine Savanna and Flatwoods (Mesic to Wet Phase)	4409	0		0	51106	55516		4409
Wet Pine Savanna and Flatwoods (Wet Phase)	35219	0			0	35219		35219
Grand Total	109023	38918	2280	474	108609	259304		153149
Compares intiial ecological classification (Simon and Heyden, 2013) and soil based analysis (Hansen et al, 2013)								
Total aquatic, wetland, riparian, marsh and aquatic combines both approaches								

On the Francis Marion, the 1996 plan estimate was about 143,000 acres of wetlands. In this initial estimate, the amount identified within the Forest for the aquatic, riparian area floodplains, linear depressions, and isolated or ecologically identified wetlands, is 153,000 acres. Essentially, all of these acres have hydric soils or isolated wetlands of various types, with smaller streams and aquatic elements embedded into the values. Approximately 59 percent of the National Forest falls into this category of riparian areas, wetlands, tidal marsh, and embedded waters. About 40,000 acres of the National Forest total are wetlands with hydric soils within linear depressions with likely aquatic and riparian connectivity dominated by loblolly, longleaf, or other pine types. The pine wetlands are about 10,000 acres less than identified in 1996 plan; there is no obvious reason for this; however, it is possible that some of the areas damaged by Hurricane Hugo could not be salvaged and converted to hardwood, hardwood pine, or other types. We are uncertain as to the specifics, but Jay Purnell (*personal communication*, Francis Marion National Forest) has suggested an increase in bottomland hardwoods since 1996. Other possible reasons could be differences in inventory methods or stand mapping.

Various methods may be used to separate wetlands, riparian areas, tidal lands, and aquatic areas into categories. In non-tidal areas, preliminary observations in groundwater-ecosystem-dependent resource sampling suggested that conductivities of water in depression wetlands above 40 micromhos/cm^2 likely had subsurface inputs from groundwater or perhaps interface with karst materials. Areas apparently fed by mostly rainfall or surface flow had lower conductivities. It is likely that there may be additional indicators that could help define and divide wetlands into additional categories relative to their water quality and hydrology inputs (e.g., Vulava et al. [2008] and Garrett et al. [2011]). However, unless there are some biological or other reasons for divisions between wetlands driven by different hydrology inputs, no substantial efforts or information based on hydrology or water quality differences has been used to divide them for planning purposes. In salt water influence zones, the levels of salinity can be used to roughly divide these areas into various types. However, the delineation line between salt and freshwater is not necessarily static or exact, and vegetative indicators are often used. The tidal heights have lunar, wind, storm, and other influences. However, the divisions have been based on best available information for the assessment stage, and separation in types may be presented with the ecological classification, but further refinement may be needed in the plan analysis phase.

There are a combination of specific and general types of wetlands with hydric soils, plants and hydrology indicators on the Francis Marion landscape (Enviromental Laboratory 1987).

- Specific types are generally well confined and relatively abrupt changes from the surrounding areas and may include Carolina bays and other isolated wetlands, pocosins, salt, brackish, or maritime marsh, springs, seeps or various types of riparian wetlands (those within riparian areas are regularly flooded areas along the channel or linear depression areas adjacent to terrace slopes along the low frequency floodplain margins that have slope runoff or seepage inputs). Wetlands may be isolated or have stream connections. Wetlands may be managed to some degree to promote their health and function, but many may be unsuitable for timber production unless they are loblolly or longleaf types. Many of the wetlands in the 1996 plan were identified as suitable for timber management. Most of the wetlands are dominated by hardwood trees.
- Loblolly and longleaf pine dominated wetlands are what could be considered general wetland types, comprising about 40,000 acres on the Francis Marion. It was thought that many of these lacked linear depression connectivity to streams unless previously modified. Recent information suggest that some these areas may be connected through linear depressions; however, they are more apt to be ephemeral or headwater intermittent stream connections. These wetlands are often natural but in some instances may be modified stands through drainage or bedding, infrequently with drainage ditching. For many of these areas, especially longleaf pine stands, prescribed fire activities are a desired component. These loblolly- and longleaf pine-dominated wetlands seem

to have no ill effects from being managed. Pine trees have an incredible ability to transpire water when it is available. Even though managed, these wetland pine stands retain hydric soil, plant, and hydrology indicators, and have some management restrictions and equipment limitations that apply to wetlands. However, if hydrologic modifications are needed to regenerate and maintain their condition in the future, they may be candidates for restoration to hardwoods.

Historical Extent of Wetlands in the State of South Carolina. Most states including South Carolina define riparian areas along streams, and have a tendency to differentiate them from wetlands, where appropriate. There is overlap in the State and Forest Service definitions of riparian areas. Table 2-24 summarizes wetland historical and recent extent estimated in South Carolina. This estimate suggests that 64 percent of the wetlands have been lost as compared to the historical or reference level. Similar, but slightly less, loss occurred across the U.S. At the time of European settlement in the early 1600s, the current U.S. area had approximately 221 million acres of wetlands, which declined to about 103 million acres in the mid-1980s (Dahl and Johnson 1991). Remarkably, 6 states lost 85 percent or more of their original wetland acreage, and 22 lost 50 percent or more (Dahl 1990).

Table 2-24. Extent of wetlands, by type

Wetland Type	Historical Acreage	1980s Reported Acreage	1994 Reported Acreage	Most Recent Acreage
Saturated Bottomland Forest	6,414,000	4,659,000	1,804,884	1,804,884
Nonforested Wetlands/Marsh			485,314	485,314

Source: SC DHEC (2012d).

Comparing the State's recent estimate of wetlands with the preliminary ecological classification (Simon and Heyden 2013) indicates there are approximately 110,700 acres of bottomland hardwood type wetlands including Carolina bays, and 2,700 acres of nonforested wetlands/marsh on the Forest. These figures suggest that 6 percent of the State's bottomland hardwood type and 0.6 percent of the non-forested wetland/marsh are contained within the Forest (1.3 percent of the State's land area). Although there is substantial uncertainty in directly comparing the numbers from two separate estimation approaches, it does suggest that the Forest wetlands are of some significance within South Carolina. In addition, approximately 40,000 acres of pine-dominated wetlands were not included in the State or the Forest bottomland forest estimate. The inference is that the Forest has historically had a substantial decline in wetlands. With currently 59 percent of the Francis Marion estimated to be wetlands of various types including pine-dominated wetlands, there is not enough land left to have the 64 percent decline that South Carolina estimated. This information coupled with the LiDAR coverage that reveals all the ditches and State and county encouragement for drainage, suggests that there probably has been a decline. However, limited effort has been made to determine an estimate of wetland loss for the Forest (South Carolina Regulations, 1911, 1920 to 1962, Berkeley County et al. 1963; Hansen et al. 2013; Simon and Heyden 2013).

Restoration of Riparian Areas and Wetlands. Restoring formerly reclaimed (drained) stands of pine back to facultative wet or obligate hardwood, a mixed stand, or other species may or may not be as simple as not bedding or plugging ditches to allow conversion back to hardwoods (see Table 2-25). Some hydrologic modifications were more or less permanent, while others may only remain effective for the existing forest stand. If maintaining pine is important to some of these prior modified areas, regeneration cuts can be done in stages to reduce tree density and provide openings for regeneration, while maintaining transpiration to the extent that water tables remain low enough for regeneration without bedding. Both loblolly and longleaf pine are facultative wetland species (Table 2-31) that can live either in wetlands or

uplands. If for some reason, such as longleaf pine is the desired species on some of these areas, it is fully acceptable to manage for longleaf as long as significant hydrologic modifications are avoided.

Table 2-25. Potential tree species that could be used for wetland restoration

Examples of Hydrophytic Tree Species Likely Found in Wetlands of the SE USA		
Obligates (>99% in Wetlands)	**Facultative Wet (66-99% in Wetlands)**	**Facultative (34%-66% in Wetlands)**
River Birch	American Sycamore	Red Maple
Water Hickory	Silver Maple	Gray Birch
Swamp Blackgum	Boxelder	Pecan
Swamp Cottonwood	Shellbark Hickory	Blackgum
Overcup Oak	Slash Pine	Loblolly Pine
Nuttail Oak	Pond Pine	Eastern Cottonwood
Bald Cypress	American Elm	Longleaf Pine
Black Willow	Swamp White Oak	Bur Oak
Water Ash	Laurel Oak	Water Oak
Water Elm	Pin Oak	Slippery Elm
Pond Cypress	Shumard Oak	Rock Elm
	Willow Oak	Green Alder
	Swamp Post Oak	
	Most willow spp.	
	Speckled Alder	
	Hazed Alder	
	Green Ash	

2.2.5.5 Hydrologic Modifications

Note: Includes ditches, roads, trams, bedding, and dikes, etc.

Hydrologic modifications were extensively discussed already. Most of these have potential for effects to water quantity and quality, as well as effects to riparian areas and wetlands. We have many new tools that enhance our ability to identify modifications, but we lack the information on current status, function, or condition of those areas modified. Recognizing that most of these are obvious with LiDAR technology, and the fact that deep ruts can remain for many decades, it is likely that many of the modifications are functioning to some extent. Severe floods and storms such as Hurricane Hugo may have damaged some of them.

The hydrological modifications across the landscape were designed by early settlers and landowners to improve access, retain water, or to drain areas for various uses or management. Some modifications were intentional, others perhaps not. These activities targeted and affected the hydrology and function of many riparian areas, streams, and wetlands. The full extent of these activities are complex and not fully documented. Activities that promoted drainage, reduced the hydroperiod by increasing the rate of water removal from the landscape, resulting in increased peak and storm flows and reduced groundwater levels and baseflow. Even with the extensive hydrological modifications, changes in soil types occur slowly and adjust very little, but biological changes probably occurred. Some of the drainage modifications influenced the extent and growth of pine lands which have affected the fuel types and loading. Wetlands, riparian areas, and associated lands have different fuel types and fire frequency from the loblolly and longleaf pine lands. However, the assumption would be that dams, ditches and dikes, roads and trams, berms, and beds continue to exert alterations of function resulting from the various types of water controls present.

2.2.5.6 Stresses and Threats

Similar to the reference water resource condition, there are numerous legacy hydrologic modification activities that were directed at to influence riparian areas, wetlands, and waters:

- The general trend of increased growth and urbanization to this area has associated stresses and threats based on water demands and people needs and wants that could influence these resources. The increased population, industrialization, port expansion, and jobs, brings Forest users, development, and many of the other things already mentioned. We have more tools today than ever before to help evaluate, find, track, treat, mitigate and/or reduce riparian area, wetland, and waters stresses and threats. However, resources immediately available to address these concerns at the Forest, State and Federal levels are more constraining than any time in recent history. Many of the coastal streams on the Forest are essentially dry during drought periods, so there are obvious water quantity and riparian connections and stresses under those circumstances.
- The climate change projections with more severe floods, winds, drought, and sea level changes add some additional stresses and threats. There is potential that some of these stresses and threats could be offset or defused with restoration efforts. There are plenty of existing and potential concerns, but there is uncertainty as to how much could be addressed and to what degree and how fast some of these projections might occur.

3 Additional System Drivers

3.1 Introduction

This section includes information regarding the primary system drivers and stressors on the Francis Marion National Forest. These include climate change, insects and disease, wildland fire/fuels, invasive species, natural vegetation succession, natural disturbance, and human disturbance.

3.2 Climate Change

The best available science information provided in this section is based on models and literature derived through the use of the Template for Assessing Climate Change Impacts and Management Options (TACCIMO) (http://www.taccimo.sgcp.ncsu.edu/).

3.2.1.1 Preliminary Findings

1. There is no direction in the 1996 Forest plan that responds to climate change.

2. Long-term monitoring on the Santee Experimental Forest found a statistically significant increase in air temperatures over the 63-year period from 1946 to 2008, with an average increase of about 0.3 °F per decade (Dai et al. 2011). Mean annual daily minimum temperatures were found to increase at an even greater rate of about 0.5 °F per decade (Dai et al. 2011). Changes in precipitation were small over the 63-year period; however, seasonally there was a slight increase in fall and winter rainfall and a decrease in spring and summer rainfall (Dai et al. 2011).

3. Future projections specific to the Francis Marion National Forest are based on the A2 (high) emissions scenario. All of the projections indicate warming with median (50th percentile) annual average temperatures increasing by 1.2 °F for the time period 2010 to 2039. Even the most conservative ensemble considered (25th percentile) estimates 1.1 °F of warming during the same time period, which is greater than the range of uncertainty considered (25 to 75th percentile) of 0.5 °F (Girvetz et al. 2009; Maurer et al. 2007).

4. Precipitation projections seem to indicate a generally wetter future, with a median increase of 2.8 percent for the 2010 to 2039 time period. However, this change is well within the range of uncertainty considered (25 to 75th percentile) of 4.0 inches for 2010 to 2039 (Girvetz et al. 2009; Maurer et al. 2007). In addition, changing climate variability is expected to continue to lead to more intense rainfall events and longer periods of drought in the future (Breshears et al. 2005).

5. All seasonal averages show warming, with the greatest change occurring in the fall and the least change occurring in the winter (increase of 1.0 °F) for the timer period 2010 to 2039. In all cases the projected changes are greater than the 25 to 75th percentile range, which represent the level of model uncertainty considered. Seasonal precipitation projections seem to indicate a trend toward a wetter fall with less pronounced changes in other seasons. However, this change is well within the range of uncertainty considered (25 to 75th percentile) of 2.3 inches for 2010 to 2039 (Girvetz et al. 2009; Maurer et al. 2007).

6. Airborne particulate matter is expected to decrease as precipitation increases; however, a climate-driven increase in wildfires can potentially increase both particulate and ozone concentrations (Jacob and Winner 2009).

7. Due to increased climate variability, destructive insects, such as bark beetles, will be better able to take advantage of forests stressed by more frequent drought (Duehl et al. 2011; Gan 2004). Certain invasive plant species, including cogongrass (Bradley et al. 2010), are expected to increase dramatically as they are able to tolerate a wide range of harsh conditions, allowing them to rapidly move into new areas (Hellmann et al. 2008).

8. Wildfire frequency is expected to increase across the Southeast region in the future (Heilman et al. 1998). Prescribed burning will remain an important tool to reduce fuels on Forest lands, but the number of days when burning is prohibited may increase, due to dry, windy conditions (Liu et al. 2012).

9. The potential for severe storms is expected to increase in the future, including less frequent but more intense hurricanes making landfall in the southern U.S. (Emanuel 2005), with potential increases in both inland flooding and coastal storm surge events (Seneviratne et al. 2012).

10. Depressional wetlands, such as Carolina bays, will be particularly vulnerable to changing climate because temperature and rainfall changes have the potential to lower groundwater table levels, altering the length of time that wetlands hold standing water (Stroh et al. 2008; Erwin 2009). Any changes in the hydrology of these wetlands may lead to forest vegetation encroachment into historically herbaceous areas (De Steven and Toner 2004).

11. Rising seas, in combination with more intense hurricanes, will alter the composition of coastal marshes (Day et al. 2008; Voss et al. 2012). Tidal forests, including bald cypress swamps, may serve as sentinels for sea-level rise, due to their low tolerance to salinity changes. The loss of tidal forests would have potentially negative consequences for wildlife species such as endangered wood storks that often nest in cypress swamps (Craft 2012).

12. Sea-level rise will increase the potential for saltwater intrusion into coastal freshwater tables. Increasing salinity of coastal aquifers may affect groundwater resources within 3 miles of the coast (Langevin and Zygnerski 2012).

13. An increase in disturbance may promote longleaf pines at the expense of loblolly pine, as longleaf pines are more resilient to wind damage (Bragg et al. 2003; Johnsen et al. 2009). Populations of bald cypress may be particularly vulnerable to future changes, including higher air and water temperatures (Middleton 2009; Middleton and McKee 2004) as well as increased salinity with sea-level rise (Krauss et al. 2009).

14. Higher temperatures will cause many species to shift ranges, generally moving to track their suitable habit (e.g., northward or up in elevation) (McKenney et al. 2007; Heller and Zavaleta 2009). However, in some cases, the rate of warming combined with land use changes will restrict the ability of plants and animals to move into suitable habitat (Hitch and Leberg 2007; Pickles et al. 2012).

15. Freshwater mussel species already declining in the region may see increased risk with future changes, as impacts from land use changes in combination with drought-induced low water levels and high summer temperatures may potentially extirpate thermally sensitive mussel populations (Galbraith et al. 2010; Golladay et al. 2004).

16. Amphibians may be most at risk among terrestrial wildlife species, due to dependencies on moisture and cool temperatures that could be altered in a future climate (Corn 2005; Blaustien et al. 2010).

17. With more days with extreme heat, recreation areas could see decreased use in the summer if temperatures impact visitor comfort (Richardson and Loomis 2004; Scott et al. 2004).

3.2.1.2 Background

The background information disclosed in this section on climate change will be used to help in the following ways:

- Determine the effects of climate change on air quality (i.e., ozone and smoke).
- Determine the effects of climate change on precipitation, evapotranspiration patterns, temperature and drought.
- Determine the effects of land use, projects, and activities, and other stressors on hydrologic and geomorphic processes and water resources. Determine the effects of climate change on sources of drinking water. Determine if rising sea level may impact ground water.
- Evaluate changes in predominant climatic regimes, evaluating climate characteristics such as precipitation, temperature, growing season, or drought.
- Evaluate broad-scale natural disturbance regimes, including wildfire, wind, hurricanes, sea-level rise, flooding, and insects and disease where applicable.
- Evaluate invasive plant species, and how this may change based on a changing climate.
- Evaluate natural vegetation succession, and how this may change based on a changing climate.
- Evaluate plant species composition and how this may change based on a changing climate.
- Evaluate the ability of ecosystems within the plan area to adapt to changes. Adaptation of ecosystems may occur through functional redundancies and/or evolutionary or behavioral adaptations of species.
- Consider the influence of changing climate on key ecosystem characteristics to evaluate their vulnerability to potential future conditions and ability to provide ecosystem services and other benefits to society.

3.2.1.3 Current Condition and Trends

The Francis Marion National Forest is experiencing increased threats from fire, insect and plant invasions, disease, extreme weather, and drought. Scientists project increases in temperature and changes in rainfall patterns that can make these threats occur more often, with more intensity, and/or for longer durations.

Current Climate

In evaluating historic climate two estimates are made for temperature and precipitation. One is based on observed (Gibson et al. 2002; PRISM) historic data, the other is based on predictive models (global climate models; GCMs). The intent of providing multiple representations of current climate is to establish a chain of logic enabling analysis of future projections at coarser scales (about 12 kilometers) with respect to historic reference conditions that are observationally based and available at finer scales (about 4 kilometers). Having both representations of current climate available supports an understanding of the strengths and weaknesses of current and future projections and limitations related to scale. The Girvetz et al. (2009) representation of current climate will serve as the baseline for comparison with future climate projections in subsequent sections of this report.

Recent Climate Change. Long-term monitoring on the Santee Experimental Forest found a statistically significant increase in air temperatures over the 63-year period from 1946 to 2008, with an average increase of about 0.3 °F per decade (Dai et al. 2011). Mean annual daily minimum temperatures were found to increase at an even greater rate of about 0.5 °F per decade (Dai et al. 2011). Changes in precipitation were small over the 63-year period; however, seasonally there was a slight increase in fall and winter rainfall and a decrease in spring and summer rainfall (Dai et al. 2011).

Current Annual and Seasonal Temperature. GCM and PRISM annual average temperature estimates for the time period 1980 to 2009 differ by 0.8 °F, with PRISM estimating 64.7 °F and the median GCM estimating 65.0 °F (Table 3-1). GCM and PRISM seasonal average estimates temperature over the same time period are quite similar in the summer, winter, and fall (less than 0.2 °F difference) and most different in the spring (differ by 0.8 °F).

Table 3-1. Summary of annual and seasonal historic temperature (°F) from 1980–2009

	Annual	Dec–Feb	Mar–May	Jun–Aug	Sep–Nov
Observed Historic (PRISM; Gibson et al. 2002)	64.7	49.0	63.7	79.9	66.1
Predicted Historic (GCM[1]; Maurer et al. 2007)	65.0	49.1	64.5	80.1	66.1

[1] Average of the median A2 ensemble value (Girvetz et al. 2009).

Current Annual and Seasonal Precipitation. GCM and PRISM annual average precipitation estimate for the time period 1980 to 2009 differ by 0.5 inches, with PRISM estimating 50.6 inches and the median GCM estimating 51.1 inches (Table 3-2). GCM and PRISM historic estimate of seasonal average estimates precipitation over the same time period are most similar in the winter and spring (differ by less than 0.3 inches) and most different in the summer and fall (0.6 inches and 1.1 inches, respectively).

Table 3-2. Summary of annual and seasonal historic precipitation (inches) from 1980–2009

	Annual	Dec–Feb	Mar–May	Jun–Aug	Sep–Nov
Observed Historic (PRISM; Gibson et al. 2002)	50.6	10.5	10.4	17.5	12.3
Predicted Historic (GCM[1]; Maurer et al. 2007)	51.1	10.6	10.7	18.1	11.2

[1] Average of the median A2 ensemble value (Girvetz et al. 2009).

Future Climate

Accounting for uncertainty is an essential step when considering projections of future climate. Uncertainty in climate projections comes from model uncertainty, uncertainty about future rates of greenhouse gas emissions, and uncertainty related to the spatial and temporal scales of analysis. Considering multiple climate models and evaluating model agreement is one approach for addressing model uncertainty. Uncertainty about future greenhouse gas emission rates is addressed by considering high (SRES A2) and low (SRES B1) emissions scenarios. However, emissions scenarios only begin to differ significantly in the second half of the 21st century and therefore model uncertainty captures the majority of uncertainty in the first half of the century. In addition, considering the high emissions scenario reduces simplifies the analysis while highlighting key trends. Finally, spatial and temporal uncertainty is addressed by comparing results for a given location and time period with results produced for broader geographic areas and longer time periods. This information is available at broader scales from previous published analyses (e.g., national and regional assessments).

The climate projections summarized within this report are drawn from a comprehensive and accessible inventory of downscaled climate data available for the conterminous U.S. The ensembles derived by Girvetz et al. (2009) provide efficient insight into the broad range of model variability from 16 nationally downscaled climate models, which is particularly valuable in the context of gauging uncertainty, especially in the near term. The 25to 75th percentile (interquartile range) of models was selected to define the range of uncertainty considered in this analysis because it captures the range that the majority of models agree on without emphasizing extremes. The analysis focused on the SRES A2 (high) emissions scenario because our planning horizon is focused on the first half of the 21st century, where emissions scenarios only differ slightly and model uncertainty is the largest contributor to overall uncertainty. In addition, considering the highest emissions (worst case) is the most useful scenario for the purposes of identifying potential issues of concern.

Future projections considered here are consistent with expectations found in the literature for the southern U.S. for both annual and seasonal projections. Karl et al. (2009) discussed annual changes ranging from 4.5 °F to 9 °F by the 2080s for the B1 and A2 scenarios, respectively. Sobolowski and Pavelsky (2012) found that seasonal temperatures would increase by 4.5 °F in the summer and 3.2 °F in the winter and spring by the time period 2040 to 2070.

Future projections specific to the Francis Marion National Forest are based on the A2 (high) emissions scenario (Girvetz et al. 2009; Maurer et al. 2007). All of the projections indicate warming with median (50th percentile) annual average temperatures increasing by 1.2 °F for the time period 2010 to 2039. Even the most conservative ensemble considered (25th percentile) estimates 1.1 °F of warming during the same time period, which is greater than the range of uncertainty considered (25 to 75th percentile) of 0.5 °F. Precipitation projections seem to indicate a generally wetter future, with a median increase of 2.8 percent for the 2010 to 2039 time period. However, this change is well within the range of uncertainty considered (25 to 75th percentile) of 4.0 inches for 2010 to 2039.

Trends in Annual Temperature and Precipitation. See Table 3-3 and Figure 3-1 and Figure 3-2.

Table 3-3. Summary of mean annual historic and future climate under the A2 scenario

Temperature (° F)						Precipitation (Inches)								
Absolute			Change			Absolute			Absolute Change			% Change		
25th	50th	75th	25th	50th	75th	25th	50th	75th	25th	50th	75th	25th	50th	75th
64.9	65.0	65.3	-	-	-	49.3	51.1	52.1	-	-	-	-	-	-
66.0	66.3	66.5	1.1	1.2	1.1	50.5	52.6	54.5	1.2	1.4	2.3	2.5	2.8	4.5
67.9	68.1	68.3	3.0	3.1	3.0	51.3	53.0	54.8	2.0	1.8	2.7	4.2	3.6	5.1
69.9	70.5	71.1	5.0	5.5	5.8	48.8	55.3	56.4	-0.5	4.2	4.3	-1.0	8.1	8.2

Source: Girvetz et al. (2009) and Maurer et al. (2007).

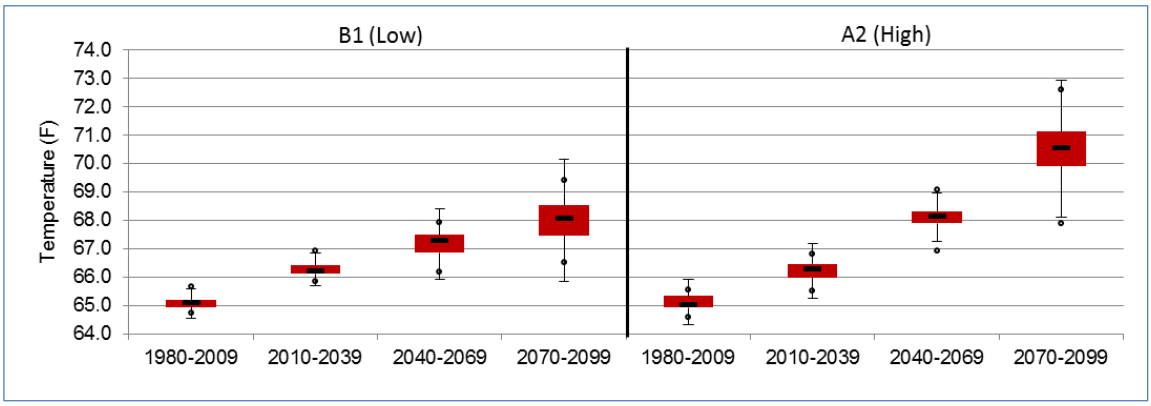


Figure 3-1. Box and whisker plots of projected mean annual temperature

Note: Box and whisker plots of projected mean annual temperature depicting the 25–75th percentile (interquartile range; IQR, or 75th percentile minus the 25th percentile) as the red box with the median value marked with a dash. The error bars represent uncertainty as calculated from 1.5*IQR, with potential outliers (maximum and minimum ensembles) represented by small circles (Girvetz et al. 2009; Maurer et al. 2007).

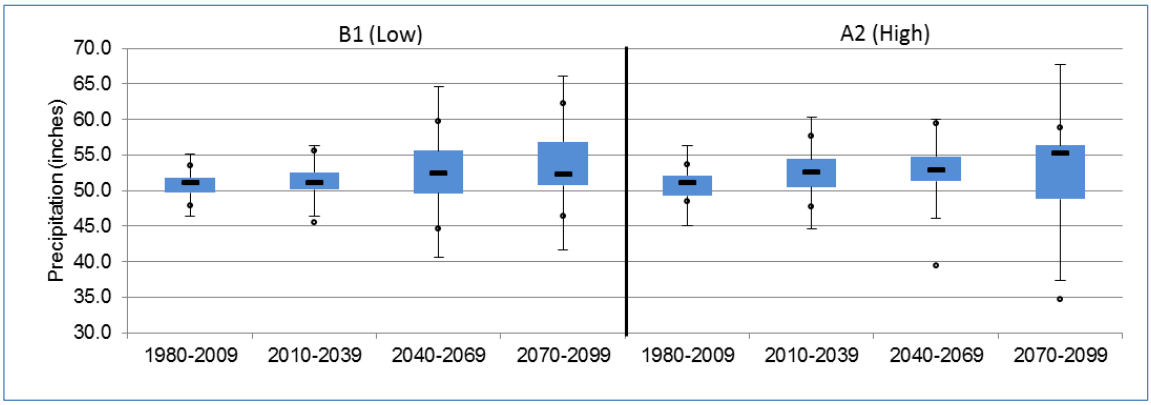


Figure 3-2. Box and whisker plots of projected mean annual precipitation

Note: Box and whisker plots of projected mean annual precipitation depicting the 25–75th percentile (interquartile range; IQR, or 75th percentile minus the 25th percentile) as the blue box with the median value marked with a dash. The error bars represent uncertainty as calculated from 1.5*IQR, with potential outliers (maximum and minimum ensembles) represented by small circles (Girvetz et al. 2009; Maurer et al. 2007).

Trends in Seasonal Temperature and Precipitation (Table 3-4; Figure 3-3 and Figure 3-4). All seasonal averages show warming, with the greatest change occurring in the fall and the least change occurring in the winter (increase of 1.0 °F) for the timer period 2010 to 2039. In all cases the projected changes are greater than the 25 to 75th percentile range, which represent the level of model uncertainty. Seasonal precipitation projections seem to indicate a trend toward a wetter fall with less pronounced changes in other seasons. However, this change is well within the range of uncertainty considered (25 to 75th percentile) of 2.3 inches for 2010 to 2039.

Table 3-4. Summary of mean seasonal historic and future climate under the A2 scenario

		Temperature (° F)						Precipitation (Inches)								
		Absolute			Change			Absolute			Absolute Change			% Change		
		25th	50th	75th	25th	50th	75th	25th	50th	75th	25th	50th	75th	25th	50th	75th
Winter	1980-2009	48.8	**49.1**	49.8	-	**-**	-	10.1	**10.6**	11.1	-	**-**	-	-	**-**	-
	2010-2039	49.8	**50.1**	50.7	1.0	**1.0**	0.9	10.1	**10.8**	11.6	0.0	**0.1**	0.5	0.5	**1.1**	4.1
	2040-2069	51.1	**51.6**	52.5	2.4	**2.5**	2.7	9.5	**10.7**	12.1	-0.6	**0.1**	1.0	-6.1	**0.5**	8.7
	2070-2099	52.9	**53.5**	54.3	4.2	**4.4**	4.5	9.9	**11.2**	12.3	-0.2	**0.5**	1.2	-2.3	**4.8**	10.4
Spring	1980-2009	64.2	**64.5**	64.9	-	**-**	-	10.2	**10.7**	11.2	-	**-**	-	-	**-**	-
	2010-2039	65.2	**65.6**	65.9	1.0	**1.1**	1.0	10.4	**11.1**	11.8	-0.8	**0.3**	0.4	2.6	**3.5**	4.7
	2040-2069	66.8	**67.4**	68.0	2.6	**2.9**	3.1	9.7	**10.5**	11.1	-1.8	**-0.5**	-0.2	-4.6	**-2.0**	-0.8
	2070-2099	69.1	**69.8**	70.5	4.9	**5.3**	5.6	9.1	**10.1**	11.1	-3.1	**-1.1**	-0.6	-10.4	**-5.7**	-1.0
Summer	1980-2009	79.9	**80.1**	80.4	-	**-**	-	17.3	**18.1**	18.8	-	**-**	-	-	**-**	-
	2010-2039	81.0	**81.3**	81.7	1.1	**1.2**	1.3	16.5	**18.1**	20.3	-0.8	**0.0**	1.5	-4.5	**0.1**	8.2
	2040-2069	83.0	**83.3**	83.8	3.1	**3.2**	3.4	16.1	**18.3**	20.6	-1.2	**0.3**	1.8	-7.2	**1.4**	9.8
	2070-2099	85.4	**85.9**	86.9	5.5	**5.8**	6.5	16.6	**18.8**	21.2	-0.7	**0.8**	2.4	-3.9	**4.2**	12.9
Fall	1980-2009	65.8	**66.1**	66.6	-	**-**	-	10.5	**11.2**	12.2	-	**-**	-	-	**-**	-
	2010-2039	67.1	**67.7**	67.9	1.3	**1.6**	1.3	11.0	**11.8**	13.3	0.5	**0.7**	1.0	4.4	**6.0**	8.6
	2040-2069	68.7	**69.5**	70.0	2.9	**3.3**	3.4	11.6	**12.5**	13.6	1.1	**1.3**	1.3	10.2	**11.4**	11.0
	2070-2099	71.1	**71.9**	73.0	5.3	**5.7**	6.4	11.8	**13.1**	14.3	1.3	**1.9**	2.0	12.2	**16.8**	16.6

Source: Girvetz et al. (2009) and Maurer et al. (2007).

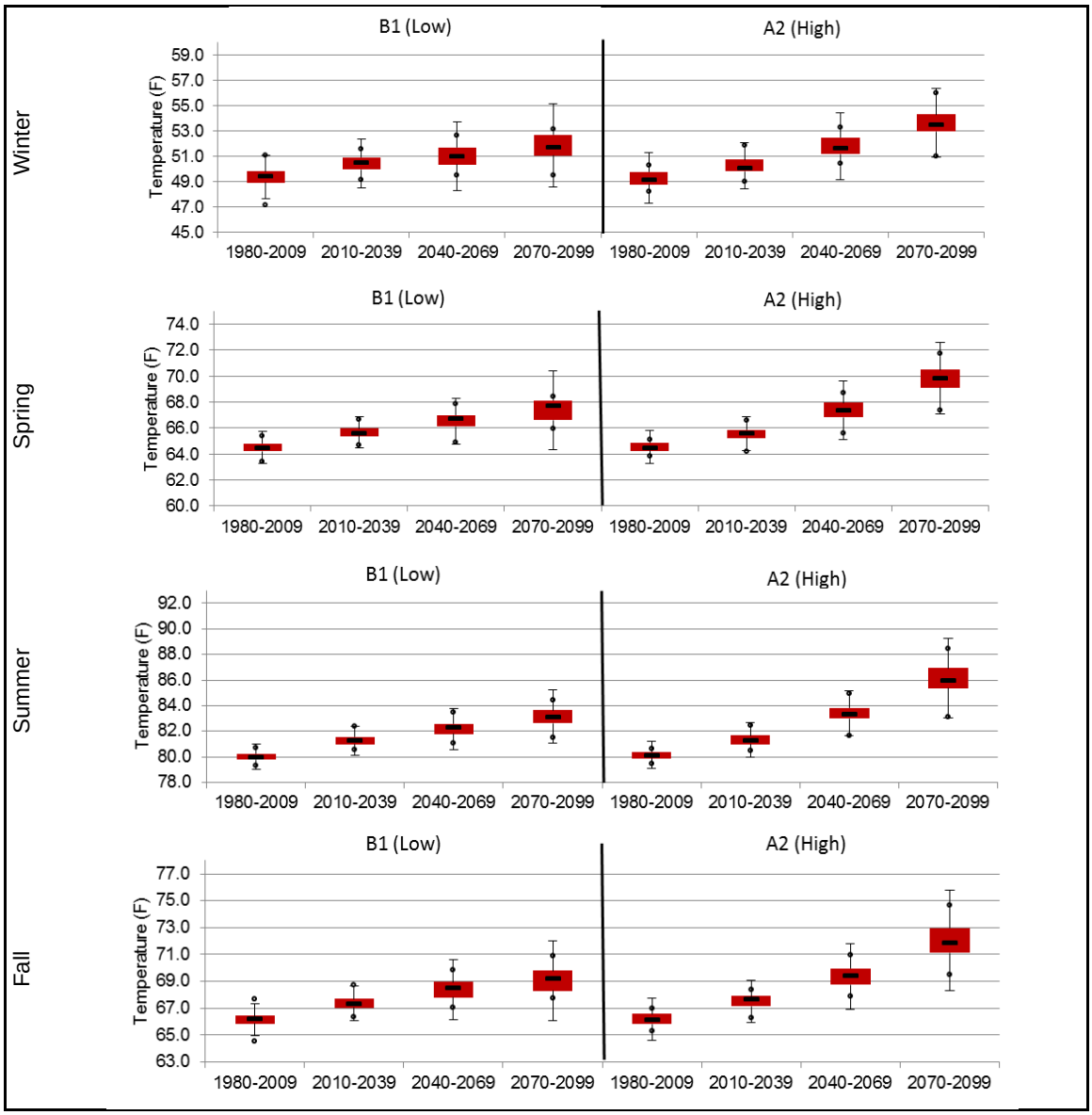


Figure 3-3. Box and whisker plots of projected mean seasonal temperature

Note: Box and whisker plots of projected mean seasonal temperature depicting the 25th–75th percentile (interquartile range; IQR, or 75th percentile minus the 25th percentile) as the red box with the median value marked with a dash. The error bars represent uncertainty as calculated from 1.5*IQR, with potential outliers (maximum and minimum ensembles) represented by small circles (Girvetz et al. 2009; Maurer et al. 2007).

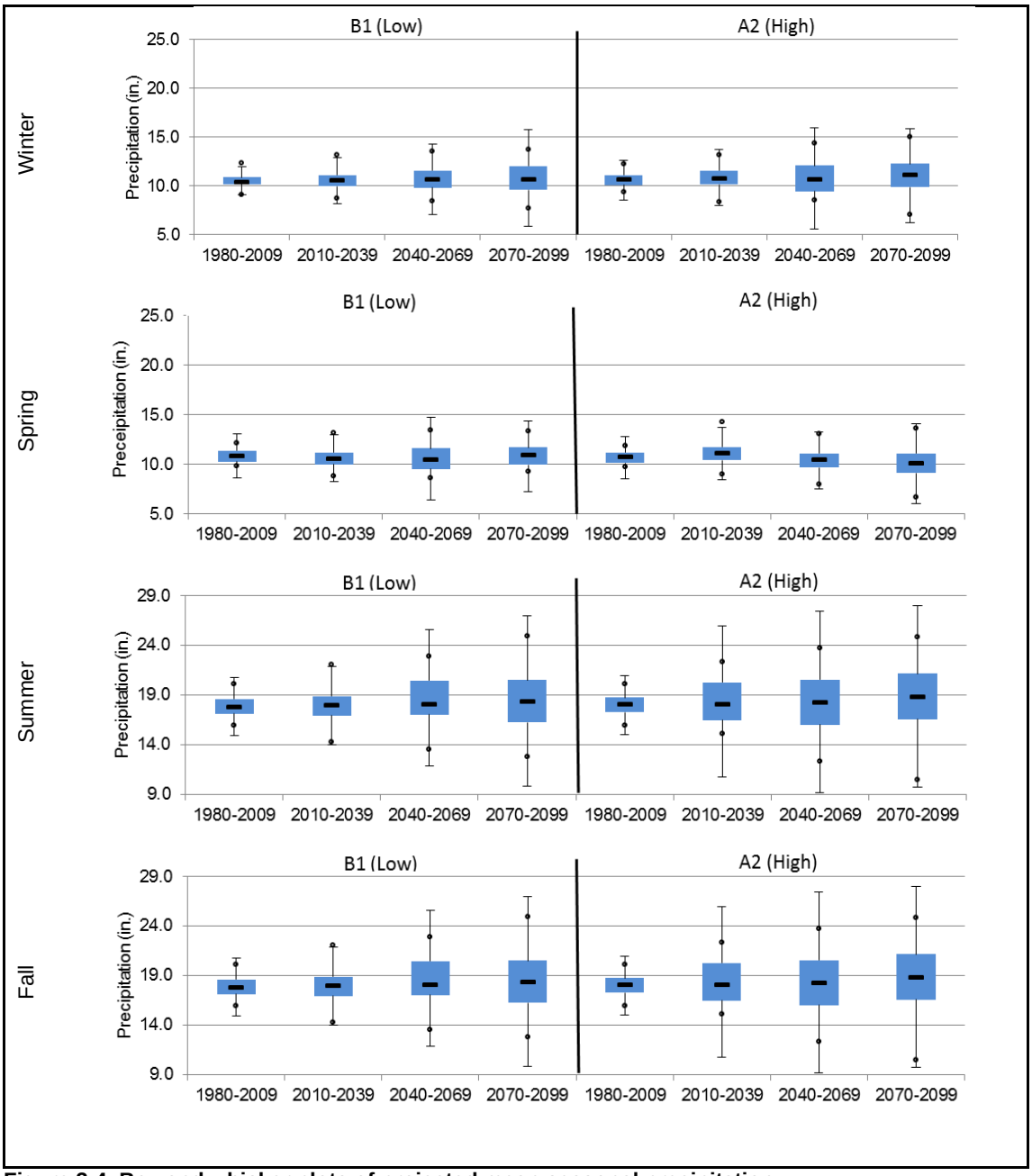


Figure 3-4. Box and whisker plots of projected mean seasonal precipitation

Note: Box and whisker plots of projected mean seasonal precipitation depicting the 25–75th percentile (interquartile range; IQR, or 75th percentile minus the 25th percentile) as the blue box with the median value marked with a dash. The error bars represent uncertainty as calculated from 1.5*IQR, with potential outliers (maximum and minimum ensembles) represented by small circles (Girvetz et al. 2009; Maurer et al. 2007).

Potential Effects of Climate Change

Air Quality. Climate change may affect the distribution patterns and concentrations of air pollutants through changing wind and precipitation patterns (Bytnerowicz et al. 2007) as well as increased temperatures (Bedsworth 2011). Increases in summer temperatures can increase the severity and duration of air pollution episodes potentially offsetting any future reductions in emissions (Wu et al. 2008). Airborne particulate matter is expected to decrease as precipitation increases; however, a climate-driven increase in wildfires can potentially increase both particulate and ozone concentrations (Jacob and Winner 2009). An increase in nitrogen deposition is also predicted (Civerolo et al. 2008), which could lead to acid loading in forest streams (McNuly and Boggs 2010).

Biological Diversity. Plants and animals at-risk will respond to environmental changes by adapting, moving, or declining (Aitken et al. 2008). Species with high genetic variation will be better able to survive in new conditions. Higher temperatures will cause many species to shift ranges, generally moving to track their suitable habit (e.g., northward or up in elevation) (McKenney et al. 2007; Heller and Zavaleta 2009). However, in some cases, the rate of warming combined with land use changes will restrict the ability of plants and animals to move into suitable habitat (Hitch and Leberg 2007; Pickles et al. 2012). The species most likely to be negatively impacted by climate change will be highly specialized and habitat restricted (Rodenhouse et al. 2009).

Forest Health. With changing climatic variability, invasive and aggressive plant and insect species may increasingly outcompete or negatively affect native species in the future (Dukes et al. 2008; Hansen et al. 2001). Winter freezes currently limit many forest pests, and higher temperatures will likely allow these species to increase in number (Morrison et al. 2005). Destructive insects, such as bark beetles, will be better able to take advantage of forests stressed by more frequent drought (Duehl et al. 2011; Gan 2004). Certain invasive plant species, including cogongrass (Bradley et al. 2010), are expected to increase dramatically as they are able to tolerate a wide range of harsh conditions, allowing them to rapidly move into new areas (Hellmann et al. 2008).

Wildland Fire and Fuels. Wildfire frequency is expected to increase across the Southeast region in the future (Heilman et al. 1998). More cloud-to-ground lightning due to warming may increase wildfire ignitions (Podur and Wotton 2010), while more frequent droughts and forest stress will lead to drier fuels which will burn more easily and at hotter temperatures, contributing to more and bigger wildfires (Flannigan et al. 2000). Prescribed burning will remain an important tool to reduce fuels on Forest lands, but the number of days when burning is prohibited may increase, due to dry, windy conditions (Liu et al. 2012).

Extreme Weather. The potential for severe storms is expected to increase in the future, including less frequent but more intense hurricanes making landfall in the southern U.S. (Emanuel 2005), with potential increases in both inland flooding and coastal storm surge events (Seneviratne et al. 2012). Hurricane events are likely to become more severe, with increased wind speeds, rainfall intensity, and storm surge height (Knutson et al. 2010; Karl et al. 2009). On the other hand, droughts have become more common in the Southeast since the 1970s, and changing climate variability is expected to continue to lead to longer periods of drought in the future (Breshears et al. 2005). As annual temperatures increase, extreme heat events will occur with increasing regularity, while the amount of freezing days will decline (Nicholls and Alexander 2007).

Water Resources. Shifts in rainfall patterns will lead to periods of flooding and drought that can significantly impact water resources (Seager et al. 2009). Increases in heavy downpours and more intense hurricanes can lead to greater erosion and more sedimentation in waterways (Karl et al. 2009; Carpenter et al. 1992). Increased periods of drought may lead to decreasing dissolved oxygen content and poor water quality in some areas (Mulholland et al. 1997). Depressional wetlands, such as Carolina bays, will be particularly vulnerable to changing climate as temperature and rainfall changes have the potential to lower groundwater table levels, altering the length of time that wetlands hold standing water (Stroh et al. 2008; Erwin 2009). Any changes in the hydrology of these wetlands may lead to forest vegetation encroachment into historically herbaceous areas (De Steven and Toner 2004). Higher temperatures will cause increased evapotranspiration that is predicted to further water stress, decreasing the water available to both forests (Lu et al. 2009) and wetlands (Pitchford 2011).

Coastal Ecosystems. Coastal areas in the Southeast have already experienced an average of 1 inch of sea-level rise per decade over the 20th century (Kemp et al. 2009), a rate that will continue to increase in the future (Pfeffer et al. 2008). Rising seas, in combination with more intense hurricanes, will alter the composition of coastal marshes (Day et al. 2008; Voss et al. 2012). As saltwater flooding expands, low-lying coastal wet forests could become marshland where land use barriers do not exist (Erwin et al. 2006). Tidal forests, including bald cypress swamps, may serve as sentinels for sea-level rise, due to their low tolerance to salinity changes. The loss of tidal forests would have potentially negative consequences for wildlife species such as endangered wood storks that often nest in cypress swamps (Craft 2012). Sea-level rise can also increase the potential for saltwater intrusion into coastal freshwater tables. Increasing salinity of coastal aquifers may affect groundwater resources within 3 miles of the coast (Langevin and Zygnerski 2012).

Terrestrial Ecosystems. Heat stress may limit the growth of some southern pines and hardwood species (Iverson et al. 2008). Additional stresses from drought, in combination with wide-scale pest outbreaks, have the potential to cause broad-scale forest dieback (Allen et al. 2010). Intensified extreme weather events, such as hurricanes, ice storms, and fire, are also expected to lead to changes in natural vegetation succession and plant community composition (Walther 2003). An increase in disturbance may promote the establishment of longleaf at the expense of loblolly pine, as longleaf pine is more resilient to wind damage (Bragg et al. 2003; Johnsen et al. 2009). Populations of bald cypress may be particularly vulnerable to future changes, including higher air and water temperatures (Middleton 2009; Middleton and McKee 2004) as well as increased salinity with sea-level rise (Krauss et al. 2009).

Aquatic Ecosystems. Increases in temperature and changes in precipitation patterns leading to lower baseflows and altered hydrology in streams and lakes will affect both plant and animal species in aquatic environments (Mulholland et al. 1997). Increased frequency of droughts can lead to poor water quality and habitat squeezes (Ficke et al. 2007), reducing diversity and increasing the incidence of waterborne diseases (Rahel and Oden 2008). Higher temperatures will negatively affect coolwater adapted fishes, including striped bass (Coutant 1990) and Atlantic and shortnose sturgeons (Waldman 2011), while warmwater adapted species may expand in range (Meyer et al. 1999). Fish kills due to high summertime temperatures are likely to become more common in shallow waters of the Southeast (Stefan et al. 2001; Fang et al. 2004). Freshwater mussel species already declining in the region may be most at-risk with future changes, as impacts from landuse changes in combination with drought-induced low water levels and high summer temperatures may potentially extirpate thermally sensitive mussel populations (Galbraith et al. 2010; Golladay et al. 2004).

Wildlife. Wildlife species will be affected in different ways, depending on their needs (Currie 2001). Amphibians may be most at-risk, due to dependencies on moisture and cool temperatures that could be altered in a future climate (Corn 2005; Blaustien et al. 2010). Birds may see a decrease in population size as vegetation types change, and heat stress makes migration more difficult (Matthews et al. 2004). In order to adapt, arrival date and nesting times of some common birds may start earlier in the year (Torti and Dunn 2005). Species with small population sizes and low genetic diversity, such as red-cockaded woodpecker, may not be able to adapt, making them susceptible to further population declines (Schiegg et al. 2002). On the other hand, populations of large mammals such as deer and bear may increase with warmer winter temperatures due to a higher winter survival rate (Ayres and Lombardero 2000).

Recreation. Environmental changes may negatively impact recreational experiences due to changes in the plant and animal communities that make those recreational experiences unique (Joyce et al. 2009; Irland et al. 2001). Fishing in coastal marshes could be affected, as intense storm events and rising sea levels may lead to degraded habitat conditions for game fish (Najjar et al. 2000). More days above freezing could increase tick and mosquito populations throughout the year (Erickson et al. 2012; Runyon et al. 2012). With more days with extreme heat, recreation areas could see decreased use in the summer if temperatures impact visitor comfort (Richardson and Loomis 2004; Scott et al. 2004).

These effects are discussed in more detail under the “Trends” sections of this report.

3.3 Insects and Disease

3.3.1.1 Preliminary Findings

1. As discussed in annual monitoring and evaluation reports, native insects and diseases have generally remained at endemic levels and not caused significant problems during the life of the current plan. Outbreaks could always occur, however, and they always seem to eventually happen with southern pine beetle where host species are present.

2. The Forest has aged 17 years since the current plan was signed. The older age classes of trees on the Forest have reduced vigor and increased susceptibility to pests. As of April 2013, 10 percent of the Forest is over 100 years of age, 29 percent is over 803. A higher expected level of tree mortality due to increased age and increased susceptibility to pests is consistent with the desired condition on page 1-4 of the 1996 plan.

3. Since this Forest plan has been in place, a new nonnative disease has come into the Forest. Laurel wilt is a disease of redbay (*Persea borbonia*) and other plant species in the family Lauraceae. It is causing widespread mortality in the coastal regions of South Carolina, Georgia, Florida, and North Carolina.

3.3.1.2 Existing Information

Several species of potentially damaging native insects and diseases remain endemic in the ecosystems of the Francis Marion National Forest. As noted in recent annual monitoring reports, two of the most common diseases, fusiform rust and annosum root rot, have remained present, but have not caused any significant problems during the life of the current plan. Southern pine beetle populations have generally been low through most of the plan period, with the exception of a small outbreak during 2002. Integrated pest management has been evident with the Forest emphasis on thinning small-diameter stands to maintain moderate stand densities, making young pine stands less susceptible to southern pine beetle attack.

Each year most Southern Region National Forests, including the Francis Marion, set out and collect traps to monitor southern pine beetle populations. From the numbers of southern pine beetles and their insect predators (clerid beetles) collected in these traps, Southern Region Forest Health personnel publish southern pine beetle trend predictions each year. Detailed trend predictions for all monitored locations in the Southern Region are posted on the Texas A&M Forest Service website. As of May 20, 2013, status and trends are not yet available. For 2012 the population status was low, with a trend of static. The South Carolina Forestry Commission (SCFC) also monitors southern pine beetle populations across the State. They do this both through trapping as described above, and with monitoring flights during the year. The SCFC typically notifies the Forest Service if they discover southern pine beetle spots on national forest land during aerial monitoring.

The Forest has aged 17 years since the current plan was signed. The older age classes of trees on the Forest have reduced vigor and increased susceptibility to pests. As of April 2013, 10 percent of the Forest is over 100 years of age, 29 percent is over 803. A higher expected level of tree mortality due to increased age and increased susceptibility to pests is consistent with the desired condition on page 1-4 of the 1996 plan.

Since this Forest plan has been in place, a new disease has come into the Forest, laurel wilt, which is a disease of redbay (*Persea borbonia*) and other plant species in the family Lauraceae. It is causing widespread mortality in the coastal regions of South Carolina, Georgia, Florida and North Carolina. The disease is caused by a fungus (*Raffaelea* species) that is introduced into trees by a nonnative insect, the redbay ambrosia beetle (*Xyleborus glabratus*), which is native to Asia and is the 12th new species of ambrosia beetle introduced into the U.S. since 1990. The disease has also been discovered in sassafras (*Sassafras albidum*) and avocado (*Persea americana*). In a few locations, the disease has also been found in individual plants of the federally endangered pondberry (*Lindera melissifolia*) and the threatened pondspice (*Litsea aestivalis*). However, it generally does not affect pondberry or pondspice due to their small size, and has not seemed to affect these species on the Francis Marion National Forest. This disease appears destined to eliminate redbay from the Francis Marion National Forest as well as throughout the rest of its range.

Integrated pest management as discussed in the desired condition in the 1996 Forest plan has been seen especially with the emphasis on commercial thinning. This has made large acreages much less susceptible to southern pine beetle attack and has maintained the health and vigor of trees in these same stands.

The Forest is likely to be affected by influences beyond its border in the future as it has been in the past, as with imported fire ants and laurel wilt for example. The risk of nonnative insect and disease introductions is increased both by travelers and by the ever increasing global economy. The proximity of the Forest to the port of Charleston further increases this risk. Predicted warmer winters, as discussed in section 3.2 “Climate Change”, increases the potential for higher populations of insects and diseases.

3.3.1.3 Current Condition and Trends

- Native insects and diseases have generally remained at endemic levels and not caused significant problems during the life of the current plan. Outbreaks could always occur.
- Increasing acreages of older forest are reducing tree vigor and increasing susceptibility to pests.

Laurel wilt is a new disease that is now established across the Francis Marion National Forest. It is not native. It is expected to eliminate redbay from the Forest.

3.4 Wildland Fire/Fuels

Over the course of the past century humankind's understanding of wildland fire continues to evolve. Utilizing the National Cohesive Wildland Fire Management Strategy, which outlines a shared vision between stakeholders in and around the Francis Marion National Forest and acts as an "all-lands" approach to wildland fire management issues, this section will assess wildland fire and its role as a primary system driver and stressor upon the affected communities and ecosystems in and around the Francis Marion National Forest.

The term wildland fire, as used in this assessment, will refer to any vegetation fire occurring in nature and is specific to either planned (prescribed) and/or unplanned (wildfire) ignitions.

A hydrologic unit (HUC) watershed is a drainage area delineated to nest in a multi-level, hierarchical drainage system. For analysis purposes, an existing HUC boundary that encompasses these lands and stakeholders will be used, when applicable or relevant, throughout this assessment.

A listing of preliminary findings can be found on pages 143-144 of this assessment.

Figure 3-5 highlights this HUC 12 watershed boundary that is being used as an analysis area boundary. Table 3-5 breaks down those ownership agencies by approximate acreage.

Table 3-5. Land ownership distribution

Ownership	Type	Approximate Acreage	Percentage
Private	Private and other land	395,399	49
	Approximate water bodies	60,000	7.3
County	Charleston County	2,758	0.34
State	Hatchery (Department of Natural Resources)	3.3	0.0004
	Heritage Preserve (Department of Natural Resources)	2,048	0.25
	State Forest (State Park Service)	7,558	0.93
	State Park (State Park Service)	292	0.036
	Wetland (Department of Natural Resources)	3.13	0.0004
	Wildlife Management Area (Department of Natural Resources)	37,703	4.63
Federal	United States Forest Service	259,344	31.91
	Department of Defense	3,768	0.46
	United States Fish and Wildlife Services	43,858	5.40
Total Analysis Area			**812,734**

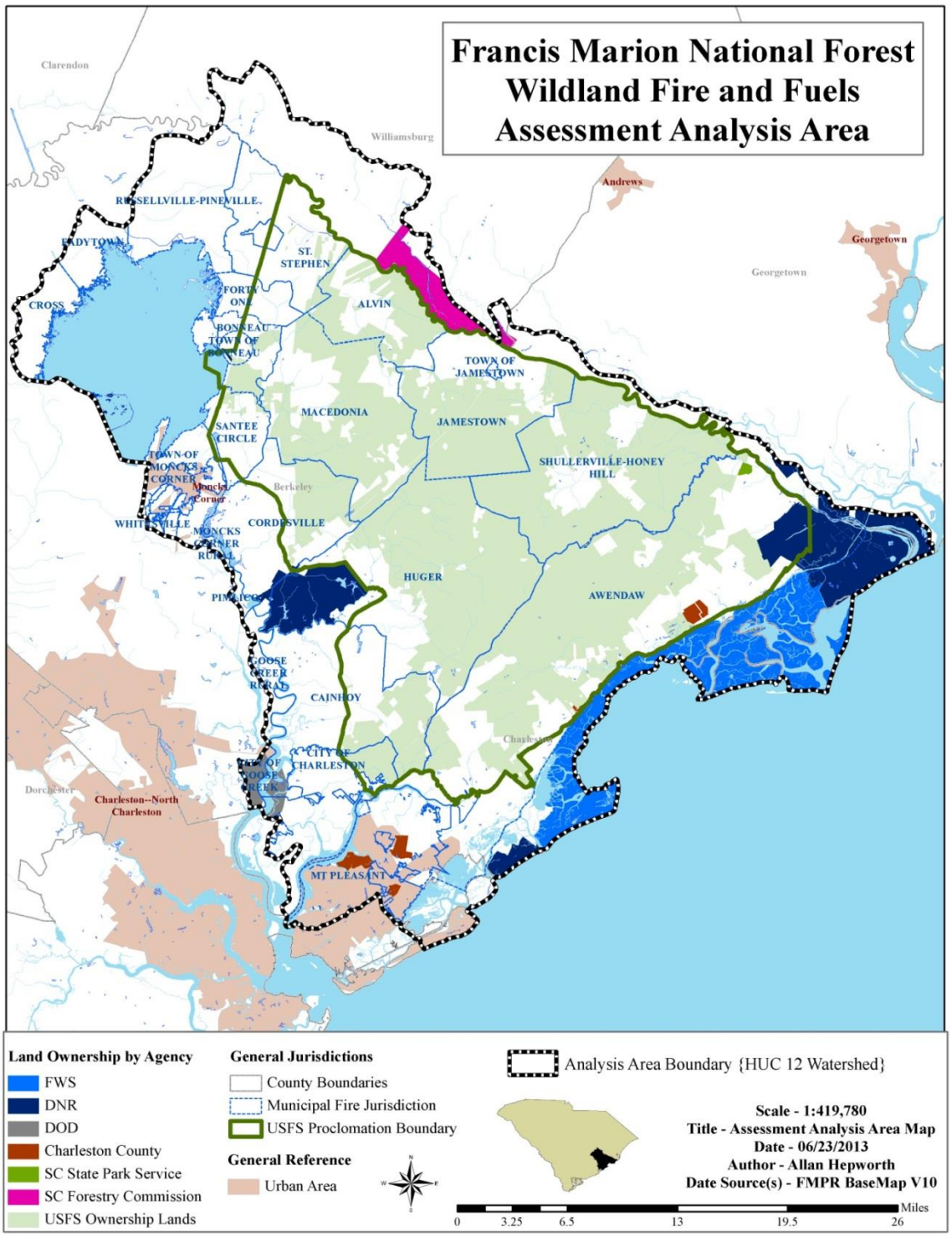


Figure 3-5. Wildland fire and fuels assessment analysis area

Both planned and unplanned ignitions have historically played a vital role in shaping and maintaining the fire-dependent ecosystems of the analysis area. Human communities ranging from dense to sparsely populated have developed in fire-adapted landscapes that require frequent burning for hazardous fuel reduction and ecosystem maintenance. The changing population and land fragmentation continue to test the ability of agencies, organizations, and landowners to deal appropriately and effectively with wildfire, while also safeguarding communities, protecting firefighters, and continuing ecosystem restoration and maintenance.

3.4.1.1 Preliminary Findings

Preliminary findings of this assessment include:

▶**Restoring and Maintaining Landscapes**

1. No other ecosystem driver, across the U.S. and specifically the Southeastern U.S., has had a more profound and influencing role upon the ecological processes of plant and animal diversity than wildland fire.

2. Partially through the implementation of prescribed fire, red-cockaded woodpecker populations are nearing 1996 Forest plan objectives (chapter 8–Fish and Wildlife).

3. From 2005 to 2012 the average accomplishment of 6,300 growing season acres burned in the longleaf forest type is below the desired.

4. An early success specific to monitoring question 1 was the expanding of the prescribed burning season into the months of May and June. Prior to 1996, the burn season concluded yearly before March 15. Prescribed burning now takes place well into the summer growing season and into May and June.

5. Since 1989 over 150,000 terrestrial acres on the Francis Marion have been restored with prescribed fire.

6. Since 2005 over 200,000 acres of maintenance burning have occurred on a 2- to 8-year frequency. Over 82,000 acres have been treated within longleaf pine systems since 2005.

▶**Creating Fire Adapted Human Communities**

7. Rapid population growth in the wildland-urban interface has become the chief cause of growing catastrophic fire loss and expenditures for combating wildfires (http://www.fs.fed.us/rm/pubs_other/rmrs_2000_cohen_j002.pdf).

8. “Wildland-urban interface per acre activity costs were estimated to be 139 percent higher than those of activities in non-wildland-urban interface areas” (Berry et al. 2006).

9. About 38 percent of the Francis Marion proclamation boundary is owned by private landowners and is increasingly fragmented.

10. About 73 percent of the analysis area wildland-urban interface falls within low density urban intermix; wildland urban intermix is comprised of structures scattered throughout the wildland with continuous fuels outside of and within developed areas.

11. Between 2005 and 2012 127,000 acres of prescribed fire maintenance and restoration burning have been implemented within wildland-urban interface defined areas of the Francis Marion.

12. Nearly 6,000 forested acres were mechanically treated in the wildland-urban interface between 2005 and 2012.

13. The Longleaf Pine Ecosystem has historically required a fire-return interval of no less than 2 to 4 years. Approximately 59 percent of Francis Marion-owned lands fall within a fire regime group I.

14. Approximately 32 percent of Forest Service-owned lands are classified as fire regime group IV; these systems are not often impacted by fire (30 to 200 years), but when impacted, it is usually a high-severity fire that is extremely difficult to control and can cause substantial risk to fire responders and affected public. The Francis Marion has over 72,000 acres of this vegetation type falling within wildland-urban interface.

►**Effectively Responding to Wildland Fire**

15. Excluding water, there are approximately 752,000 terrestrial acres protected from wildfire by Federal, state, county, and city agencies within the analysis area. Adding to the complexity, each responsible agency operates with differing regulations, policy, budgets, and authorities.

16. Between 1992 and 2012 over one-third (six) of South Carolina's wildfires over 1,000 acres occurred in the analysis area. Four of these wildfires occurred on the Francis Marion.

17. About 98 percent of all wildland fires within the analysis areas have been suppressed at less than 10 acres.

►**Miscellaneous**

18. The effects of climate change will impact wildland fire; research points to rising temperatures, dryer conditions, and increased lightning in the future. Another impact of climate change may be to the ability to utilize prescribed fire: The length of months with high or extreme fire potential levels could increase by 1 to 3 months in the Southeast.

3.4.1.2 Existing Information

As wildland fire continues to play a critical role in shaping and maintaining ecosystems within the Southeastern United States, there is much existing information available. This assessment contains a concise summary of the available information coupled with a thorough analysis of existing conditions. Within the references section of the assessment are the best available sciences used.

3.4.1.3 Background (Reference Period Disturbance Regimes)

Regional Perspective

No other ecosystem driver, across the U.S. and specifically the Southeastern U.S., has had a more profound and influencing role upon the ecological processes of plant and animal diversity than wildland fire. Furthermore, some 95 percent of the forest, shrubland, and grassland ecosystems of the Southeastern United States Coastal Plain have been shaped by the occurrence

of fire (Frost 1993). The current health of southern ecosystems can be attributed to the role of fire, the presence or lack thereof, and the implementation of policies and/or practices throughout the past several hundred years.

In 1996, after decades of studying the soil-vegetation complex of slope, aspect, moisture, evapotranspiration, insolation and temperature extremes, Frost (1998) published an approximation map of presettlement fire frequency regions of the U.S. This map highlighted the higher fire-return intervals (fire regime frequency) of each landscape unit. Figure 3-6 is clipped to show the Southeastern Region of the U.S (Frost 1998). Fire regime refers to the long-term nature of fire in an ecosystem (Brown 2000), and includes frequency and severity of effects.

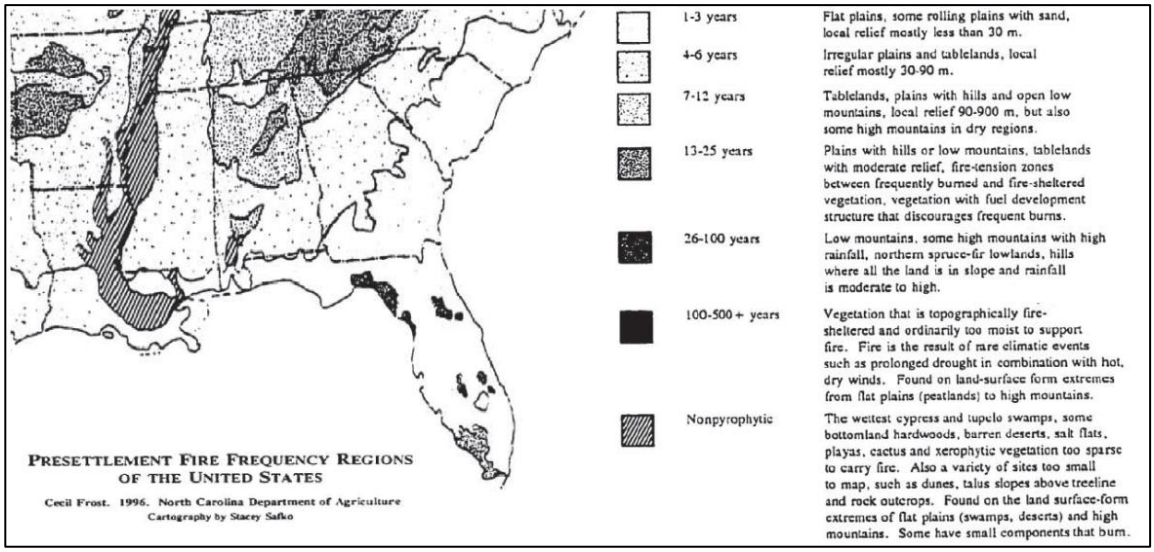


Figure 3-6. Presettlement fire frequency regions of the United States

Numerous studies and evidence suggest that wildland fire played a critical role in maintaining Southeastern ecosystems since before the coming of humans (Cooper 1961; Komarek 1965, 1974; Van Lear and Waldrop 1989). Scientists believe that naturally occurring fire from lightning, in addition to utilitarian anthropogenic fire use by Native Americans and early European settlers, caused frequent fire occurrence across the Southern States (Table 3-6) for a time spanning more than 10,000 years (Fowler and Konopik 2007).

Table 3-6. Major periods of human-caused fire regimes in the South

Fire Regime	Native American Pre history	Early European Settlers	Industrialization	Fire Suppression	Fire Management
Dates	12,500 BP to 1500s AD	1500s AD to 1700s AD	1800s to 1900s	1920s to 1940s/1980s	1940s/80s to present
Typical Burns	Low intensity brush fires	Low intensity brush fires mainly for agricultural purposes	Stand-replacing fires set by loggers and farmers	Federal lands protected from fire	Prescribed fires of mixed intensity and frequency

Williams, in his paper References on the American Indian Use of Fire in Ecosystems (2001), compiled a summary list of 11 major reasons for American Indian ecosystem burning: hunting; crop management; improve growth and yields; fireproof areas; insect collection; pest management; warfare and signaling; economic extortion; clearing area for travel; felling trees; and clearing riparian areas.

Some particularly interesting observations relating to aboriginal (Native Americans) ignitions were published by Kay (2007). Kay first describes the lighting:fire ignition ratio in the eastern United States forests as being very low historically over the past 10,000 years; over the past 43 years, since 1970, the Francis Marion has reported 57 lightning fires for an average of 1.3 fires a year. An average of 3.4 lightning fires has been reported in the analysis area since 1992. Kay argues that prior to European settlement much of the eastern U.S was dominated by oaks, the American chestnut, and pines, "…all fire-tolerant, early to mid-successional species. Since European settlement, however, oaks and pines have increasingly been replaced by late-successional, fire-sensitive species, such as maples, even in protected areas". Kay argues that since these fire-tolerant species were being maintained for thousands of years by frequent burning and that this frequent burning was not typically started by lighting, it is believed that the forest systems had "regularly been burned by native people as part of aboriginal land management activities" (Kay 2007).

During the early settlement period, European settlers in many parts of the South adapted the burning practices of Native Americans in order to produce forage for wild game and grazing animals (Fowler and Konopik 2007). With the introduction of livestock to Florida by Spanish explorers in the 16th century (Grelen 1978), the utilization of fire for wildlife forage purposes shifted to include forage for cattle.

Local Role of Wildland Fire

Wildland fire has played an essential role in maintaining Coastal South Carolina ecosystems for thousands of years (Fowler and Konopik 2007). Historical accounts of anthropogenic fire, or fires started and controlled by Native Americans, reveal that fire was used as a tool for hunting, enhancing plant resources, as well as managing the landscape. Fire, therefore, played an integral role in maintaining coastal vegetation composition (Duncan and Mitchell 2009). These recurring and frequent fires cleaned out the forest floor and recycled nutrients, while doing little damage to plants and animals. These frequent, low-severity fires enhanced the Long Leaf Pine Ecosystem, due to the longleaf pines ability to not only survive wildfires, but also to thrive and regenerate after fire occurrences, where other competing vegetation could not (Joint Fire Science Program 2009).

Throughout the past several hundred years, agriculture, urban growth, and wildland fire suppression, have completely altered these natural fire cycles and fire exclusion has created a dangerous trend of larger, faster, and more destructive wildfires (Duncan and Mitchell 2009). The effects of these aforementioned fire-spread inhibitors have been dramatic in terms of large scale fuel accumulations and changing structure and composition of within many forest communities in South Carolina (Fairchilds and Trettin 2006).

Prescribed Burning to Support Ungulate Grazing

There is a written history of colonial cattle grazing in the early 18th century on lands falling within the analysis area. This information comes from a history of Hampton Plantation, now known as the Hampton Plantation State Historic Site, located within compartment 129 of the Francis Marion. This history notes 15 different landowners who owned and managed livestock operations. Joseph Spencer in particular owned 128 cattle, 77 sheep, 3 hogs and 5 horses in the

year 1730 (Morgan, *personal communication*, email). It is important to note the following quote from the written history:

> Though Spencer's herd was relatively large, his use of the land for cattle-raising was common in the region during the early 18th century. Planters allowed their stock to range freely, uncontained by fences, through the Lowcountry pine woods, savannas, swamps and marsh lands. Like Native Americans, European setters also used fire, periodically burning grazing areas to encourage growth of grasses and to improve the pasturage. Historians believe that this use of fire had its origins both in Native American and Caribbean practice:
>
> > By demonstrating the utility of fire, Native Americans handed the settlers who followed a tool for increasing the grazing burdens of natural pastures. Planters in Barbados, the Leewards, and Jamaica . . . followed their predecessors' [the Spanish] example, tending cattle on horseback, calling grasslands "savannas," and burning them to generate new growth during droughts. West Indian migrants imported these techniques to Carolina.
>
> Frequent human-set fires kept the woods open and limited understory growth. Cattle may have also altered species composition as they browsed on young hardwood sprouts and shrubs. In the process the landscape became even more open. Hampton, as a specific place in the Lowcountry, had all of these ingredients. It had upland areas of pine forest, lowland swamps and marsh, and possibly even savanna areas. It also had cattle, as well as Native Americans and colonists to set the woods on fire for various reasons. For this early period, and probably well into the 20th century, much of Hampton's landscape was affected by fire.

The written history of the Hampton Plantation supports the observation that both Native Americans and European settlers were using fire as a tool to maintain the landscape for forage purposes in the early 18th century.

Additionally, within the history are references to cattle raising and grazing in the early 20th century:

> Rutledge, his tenants and surrounding landholders continued using the forest much as their forebears had for the past two centuries. Its primary economic function still remained grazing, and in 1905 a federal forester noted that cattle-raising was an important source of income for farmers in the area. This traditional activity continued to determine the appearance and ecology of the forests:
>
> > Ever since the settlement of this country it has been customary to burn over the pine lands every spring, to improve pasturage and prevent growth of underbrush.

Localized Fire Regimes

Figure 3-7 displays mean fire return intervals (MFRI) of the analysis area. As depicted here, MFRI describes the average time period between natural fire disturbance. In order to accurately display and analyze MFRI, two separate products along with several sources listed in the reference section, have been used. First, the spatial representation of MFRI for the Francis Marion is based on the terrestrial ecosystems 1st approximation as analyzed in section 2.1.1 "Terrestrial Ecosystems." MFRI for lands outside the Francis Marion and within the analysis area were extracted from LANDFIRE. MFRI data extracted from the LANDFIRE Vegetation

Dynamics Model Database V.1.0.0 provided the best available record (Table 3-7). Second, each terrestrial ecosystem was given an MFRI attribute from the LANDFIRE database and then displayed here. For specific information pertaining to the terrestrial ecosystems used here, please see 2.1.1 "Terrestrial Ecosystems."

It is important to note that the cross walking of MFRI to the terrestrial ecosystem 1st approximation was done using best available resources. The MFRI, as based upon the terrestrial ecosystem 1st approximation, should be considered as being very general with additional validation required if these return intervals were to be used for decision making purposes.

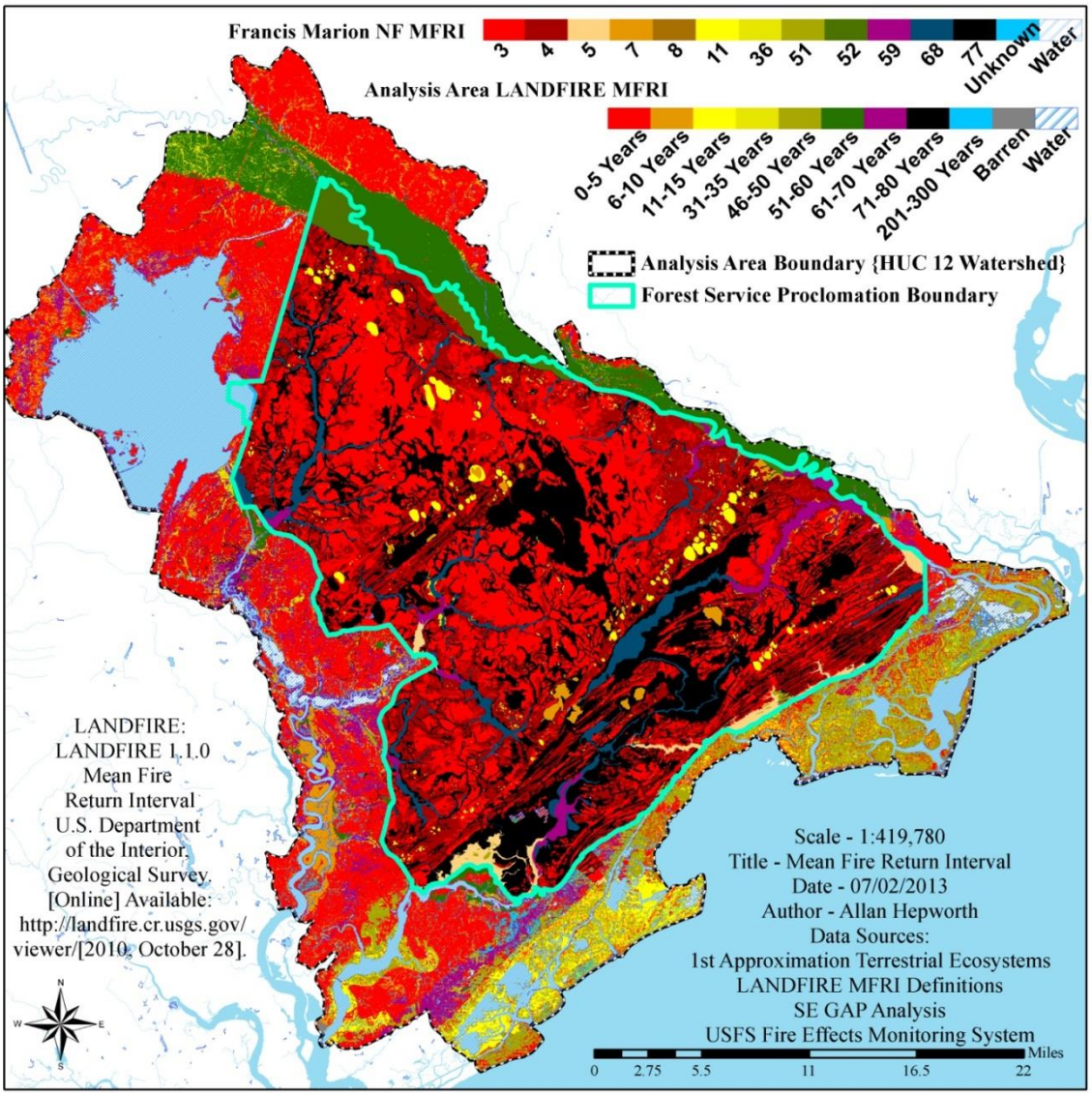


Figure 3-7. Mean fire return interval of the Francis Marion National Forest

Table 3-7 describes the fire regime group in terms of fire return frequency and severity type.

Table 3-7. Fire regime groups and descriptions

Fire Regime Group	Fire Frequency	Fire Severity Type	Severity Description
I	0–35 years	Low/mixed	Generally low-severity fires replacing less than 25% of the dominant overstory vegetation; can include mixed-severity fires that replace up to 75% of the overstory
II	0–35 years	Replacement	High-severity fires replacing greater than 75% of the dominant overstory vegetation
III	35–200 years	Low/mixed	Generally mixed-severity; can also include low severity fires
IV	35–200 years	Replacement	High-severity fires
V	200+years	Replacement/any	Generally replacement severity; can include any severity type in this frequency range

Wildland fire has historically played an important role in defining and maintaining the ecological systems of the Francis Marion. Along with a frequent fire regime, fire severity type can also be used to understand wildland fire characteristics. Table 3-8 describes the general breakdown in Forest Service acres by fire regime group; the important finding here is that although over half of the Forest is comprised of systems that historically burned on 0- to 35-year frequency, 32 percent of the Forest is comprised of fire regime group IV systems that have historically burned on a 35- to 200-year frequency as a high-severity fire. The consequences here are that these fire regimes can exhibit characteristics of extreme fire behavior when they burn and are very difficult to control under the weather conditions that allow them to burn. Having fire burn under these conditions in the wildland-urban interface heightens the risk to fire responders and the affected public.

Table 3-8. Francis Marion fire severity type acreage breakdown

Fire Regime Group	Acres Ownership	Percent of Ownership	Acres Proclamation	Percent of Proclamation
I - Low/Mixed	154,359	59%	256,959	61%
II - Replacement	2,568	1%	6,663	2%
III - Low/Mixed	20,931	8%	36,340	9%
IV - Replacement	83,085	32%	116,521	28%
Water and Altered	132	<1%	2,201	1%

Table 3-9 describes each vegetation community with assigned LANDFIRE MFRI attributes. Under the Low, Mixed, and Stand Replacement Severity columns, each community has been assigned an average MFRI and a percent fire type occurrence.

Table 3-9. MFRI Breakdown (as based upon the LANDFIRE Vegetation Dynamics Model Database) and terrestrial ecosystems

			Fire Return Interval per Fire Type with % of Fire Type Occurrence (Years/%)			Acres	
Vegetation Community	**MFRI**	**Fire Regime Group**	**Low Severity**	**Mixed Severity**	**Stand Replacement Severity**	**FS Owned**	**FS Admin**
Wet Pine Savanna and Flatwoods	3	I	3.2/96%	400/1%	100/3%	90,735	138,323
Nonriverine Swamp and Wet Hardwood Forest	77	IV		435/18%	93/82%	80,602	113,774
Upland Longleaf Pine Woodland	4	I	4/96%	370/1%	132/3%	53,856	106,134
Small Blackwater River Floodplain Forest and Blackwater Stream Floodplain Forest	68	III	130/53%	203/34%	500/13%	11,374	19,096
Tidal Wooded Swamp	59	III	63/93%		900/7%	5,217	7,866
Large River Floodplain Forest	52	III	100/52%		110/48%	3,710	8,677
Carolina Bay Wetland	11	I	14/75%	312/4%	50/21%	3,264	4,511
Salt and Brackish Tidal Marsh[1]	5	II			5/100%	2,568	6,663
Nonriverine Basin Swamp	77	IV		435/18%	93/82%	2,483	2,747
Peatland Pocosin and Canebrake	7	I		16/47%	14/53%	2,279	2,295
Depression Pond	11	I	14/75%	312/4%	50/21%	3,264	4,511
Dry and Dry-Mesic Oak Forest	7	I	8/89%	100/7%	200/4%	885	1,109
Maritime Forest	51	III	117/44%	120/44%	370/14%	416	476
Mesic Slope Forest	36	III	52/69%	161/22%	400/9%	214	225
Altered Land	Un-known	Various				77	553
Streamhead Seepage Swamp, Pocosin and Baygall	8	I	16/51%	24/34%	58/15%	76	76
Water	Water	Water				55	1,648

[1] Salt and Brackish Tidal March MFRI data came from the Forest Service Fire Effects Information System (FEIS).

3.4.1.4 Current Conditions and Trends

Unplanned ignitions present a significant and growing threat to people and landscapes throughout the Coastal Plain of South Carolina and specifically the area in and around the analysis area. Each year an average of about 2,400 unplanned ignitions burn a total of 19,000 acres on these Coastal Plain lands in South Carolina (Figure 3-8). Ninety-five percent of these wildfires potentially involve the wildland-urban interface (ForestEncyclopedia.net). Of the 416,640 acres that fall within the Francis Marion proclamation boundary, approximately 38 percent are fragmented and owned by entities other than the Forest Service. Population growth has recently outpaced other parts of the nation, leading to the development of dense human communities in extensive fire adapted landscapes that require frequent burning for hazardous fuel reduction and ecosystem maintenance. The changing population and land fragmentation is testing the ability of agencies, organizations, and landowners to deal appropriately and effectively with wildfire, while also safeguarding communities, protecting firefighters and treating the landscape.

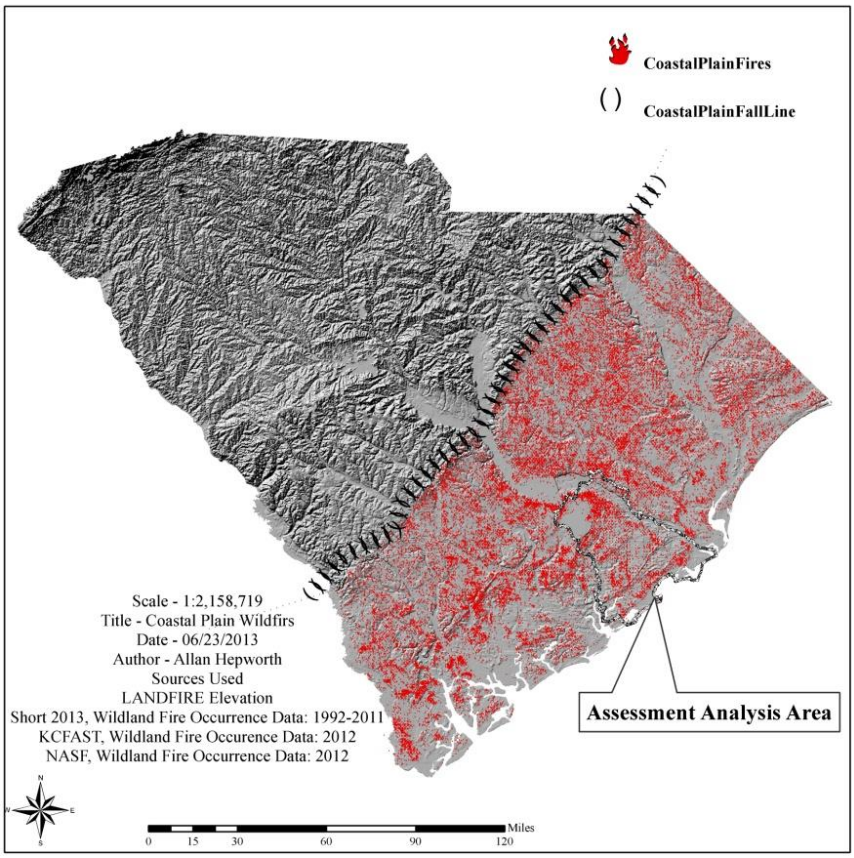


Figure 3-8. Coastal Plain fires

Major factors influencing wildland fire management include:

- *Year-round fire season:* unplanned ignitions burn 12 months a year, which stresses firefighting capacity and resources.
- *Significant wildfire activity and prescribed fire need:* between 2001 and 2010 nearly half of the national ignitions and over 40 percent of the Nation's largest wildfires occurred in the Southeast, which requires significant resources and tremendous firefighting capacity

(National Interagency Coordination Center). Coinciding with this pull for local resources throughout the Southeast is the need to implement fuels reduction and prescribed fire at the local level.

- *Large and rapidly expanding wildland-urban interface:* Driven by swiftly expanding population growth and urbanization. The Southern U.S. is projected to experience the largest decline in forest area by 2060, losing about 17 million acres in one population growth scenario. These large losses in the South reflect both an abundant forest resource and the region with the highest projected population growth and urbanization (Bowker et al. 2012)
- *Smoke management poses a significant challenge for wildland fire managers:* Smoke can impact safety, health, and quality of life. Prescribed burning produces smoke, which is a mixture of toxic particles and gases. If not carefully managed, smoke can be a nuisance to residents and businesses, and it can adversely impact community health. Smoke can contribute levels of pollution that exceed health protective air quality standards.
- *There are approximately 752,000 terrestrial acres protected from wildfire by Federal, state, county, and city agencies within the analysis area.*
- *Privately owned working forests:* nearly 38 percent of the Francis Marion proclamation boundary is owned by private landowners and is increasingly fragmented. This fragmentation significantly complicates wildland fire management due to inherent challenges working with numerous private landowners. Additionally, private landowners own land for a diversity of reasons, some of which may conflict with managing for wildfire protection or inhibit response.
- *The area in and around the Forest is comprised of land with frequent fire regime requirements:* fuel growth is rapid and fire return interval is short, which requires frequent retreatment of fuels.
- *Invasive species:* some spread rapidly after fire, contributing to fuel loading and otherwise influence forest health.

Though by no means the only factors related to wildland fire activity locally, these bullets represent several common and reoccurring factors wildland fire management and response. With the majority of land fragmented and in private ownership, wildland fire management is significantly more complicated in the Coastal Plain of South Carolina and in the Southeast than it is in other areas of the country.

The National Cohesive Wildland Fire Management Strategy (Cohesive Strategy) is a multilateral effort by Federal, state, local, and tribal governments, non-governmental organizations and other partners, working to address wildfire challenges across all lands and jurisdictions in a collaborative manner. The Cohesive Strategy has adopted three principal goals that summarize the most significant fire-related challenges and opportunities for positive change. These goals are now being implemented by wildland fire managers and will serve here as the structure and organization for the remainder of this assessment.

The three goals, discussed in the following subsections, were defined by the National Strategy Committee and adopted by the Southern Regional Strategy Committee:

- Restoring and maintaining resilient landscapes,
- Creating fire-adapted human communities, and

- Effectively responding to wildfire.

Restoring and Maintaining Resilient Landscapes

Goals and Objectives as Defined within the 1996 Forest Plan

The Revised Francis Marion National Forest Land and Resource Management Plan (Forest plan) defines the following goals and objectives:

Goals 1, 6, 7, and 8 describe future conditions with strategic wildland fire and fuels objectives.

- Objective 1 of the Forest plan states "Maintain a red-cockaded woodpecker population of 450 clusters".
- Objective 5 states "Restore the role of growing-season fires on 16,000 acres of longleaf forest types in the next 10 years and on 40,000 acres in the long term by burning on a 4-year cycle".

The red-cockaded woodpecker population is maintained, and the Longleaf Pine Ecosystem is maintained, restored, and enhanced with the use of fire.

Monitoring

Monitoring question B-6 is responsive to goals 1, 6, 7 and 8 and objectives 1 and 5 of the Forest plan.

Monitoring question B-6 asks "Are sufficient longleaf pine management type acres being burned on a 2- to 4-year growing season burn cycle to achieve objectives"?

In order to determine to monitor effectiveness, several factors are observed:

1. Annual acres and location of longleaf pine management type stands burned on a 2- to 4-year cycle during the growing season (April–September).
2. Percent of the 160,000 Red-cockaded Woodpecker Habitat Management Area (HMA) acres which has been prescribed burned in the past.
3. Percent of the longleaf pine forest types which have been prescribed burned in the last 5 years.
4. Percent of management area 26 that has been burned in the last 3 years.

Results

Planned ignitions play an integral role in maintaining biodiversity and reducing hazardous fuels on the Forest. The Francis Marion is within the range of the Longleaf Pine Ecosystem, a fire-dependent ecosystem which harbors habitat for several fire-dependent federally-listed species. Forest regrowth following Hurricane Hugo, which struck the Forest in 1989, created heavy fuel accumulations which can be conducive to intense wildfires. In the time since the Revised Francis Marion National Forest Land and Resource Management Plan was signed and implemented in 1996, the Forest has successfully achieved over 150,000 acres of prescribed fire restoration. Since 2005, over 200,000 acres were maintenance-burned on a 2- to 8-year frequency.

Prescribed fire accomplishments prior to 2007 have been accessed and are recorded in the Comprehensive Evaluation Report (CER) of 2008. Prescribed fire accomplishments since 2007 have varied from year to year with the highest acreage of 40,263 being achieved in fiscal year

2008 and the lowest acres occurring in 2012. During fiscal years 2007–12 over 200,000 total acres of ecosystem were treated with prescribed fire.

Many variables influence the Forest's ability to meet the current prescribed fire goals. Factors that can constitute a barrier to the implementation of prescribed burns are air quality concerns, policy, practitioner concerns about smoke management, public concern about resource damage, weather, escape, and lack of resources (Southeastern Regional Assessment, Cohesive Strategy). The expanding wildland-urban interface and its associated fire suppression costs also limit burning opportunities. At times, budget constraints limit the availability of personnel and equipment.

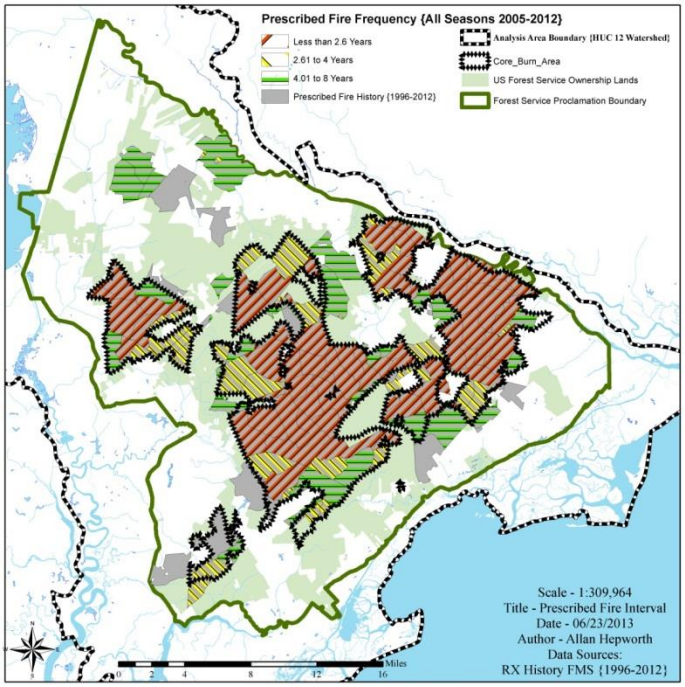


Figure 3-9. Prescribed fire burn frequency

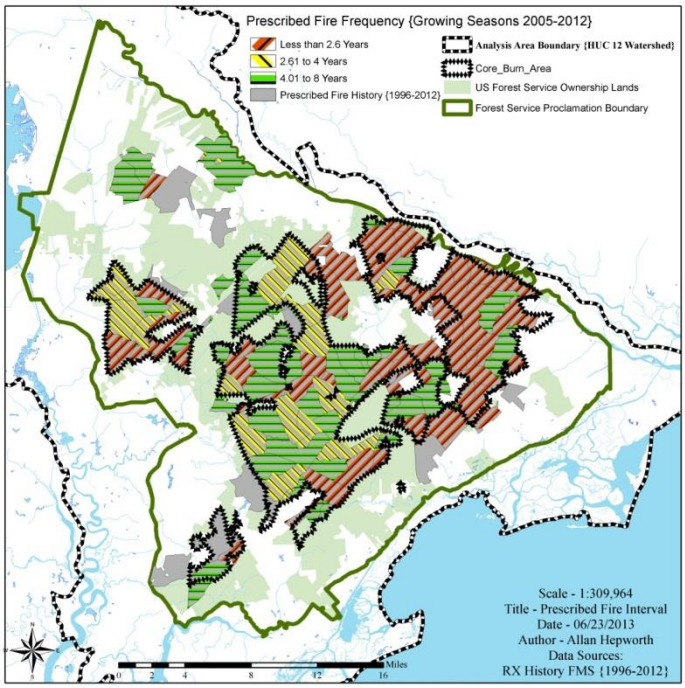


Figure 3-10. Growing season prescribed fire frequency

- Growing season prescribed burning tries to maintain a target of 16,000 acres annually (CER 2008). Figure 3-10 displays spatial patterns of growing season frequency.
    - An early success specific to monitoring question 1 was the expanding of the prescribed burning season into the months of May and June. Prior to 1996, the burn season concluded yearly before March 15. Prescribed burning now takes place well into the summer growing season and into the months of May and June.
    - The average growing season accomplishment of 10,000 acres is below the desired (see Table 3-10).
- The desired condition for the Forest is to maintain fire adapted ecosystems using a fire-return interval of once every 3 years (Forest Plan 1996). The total area that would benefit from fire is approximately 160,000 acres.
    - The current levels of treating 30,000–40,000 acres per year falls short of the 53,000 acres needed.
- Fire is critical to restoring and maintaining red-cockaded woodpecker habitat and fire-dependent communities, thus strategies to increase the number of acres burned annually are needed (Forest Plan 1996). GIS data specific to red-cockaded woodpecker habitat is not available; district personnel have historically monitored trends and assessed success (see section 8.3 "Fish and Wildlife."

Table 3-10. Percent of 160,000 burned by season

Fire Frequency (2005 to 2012)	Growing Season	Dormant Season	All Seasons
Less than 2.6 Years	6%	27%	54%
2.61 to 4 Year	14%	25%	19%
4.01 to 8 Year	36%	31%	23%

Table 3-11. Forest plan monitoring questions

	Fiscal Year Accomplishments (Acres)					
Monitor Item	FY08	FY09	FY10	FY11	FY12	Desired Condition
1	13,510	5,298	8,030	2,028	3,066[1]	See objective 5
2 [2]	50%	50%	50%	50%	50%	See objective 1 Prescribed burning cycle of 2–5 years throughout the entire HMA (ROD-red-cockaded woodpecker FEIS and standard FW-83)
3	60%	67%	67%	68%	66%	See objective 1
4	44%	48%	29%	25%	21%	MA-26-G-1 states "Restore expand and maintain the longleaf pine ecosystem and related fire-dependent communities." Standard MA-26-2 states burn pine stands on a 2–3 year cycle.

[1] The decrease in percent burned for #3 and #4 can be attributed to the burn data that was used. Last year the burn data for some years was the more generalized burn unit instead of the actual burn area. We have refined the burn history data since then.

[2] This is an estimate from district personnel. The red-cockaded woodpecker HMA is not available in a GIS layer and is not currently an accurate measure of habitat that is being managed for the benefit of the red-cockaded woodpecker.

Table 3-12. Prescribed fire accomplishment by season

	Dormant Acres		Growing Season Acres		All Acres	All Acres
FY	Longleaf	Total All Veg Types	Longleaf	Total All Veg Types	Longleaf Total	All Veg Types
1997[1]		14,141		4,960		19,101
1998[1]		20,396		13,038		33,434
1999[1]		19,210		9,286		28,496
2000[1]		18,987		11,077		30,064
2001[1]		22,269		13,017		35,286
2002[1]		18,668		4,568		23,236
2003[1]		18,114		22,580		40,694
2004[1]		23,588		8,010		31,598
2005[1]		24,351		12,100		36,451
2006	7,140	19,521	5,029	11,409	12,169	30,930
2007	8,546	24,008	2,688	10,501	11,234	34,509
2008	9,859	25,539	4,426	13,710	14,286	39,249
2009	9,908	28,985	2,560	5,894	12,468	34,879
2010	10,865	25,933	2,130	7,572	12,996	33,505
2011	5,360	17,304	4,980	14,136	10,341	31,440
2012	7,586	21,380	1,813	8,964	9,399	30,344

[1] Dormant/growing season acreage breakdown not available.

Note: Longleaf acreage is estimated using spatial analysis of burn units and veg types. Data extracted from local reports, local GIS, and Forest Service ACtivity Tracking Systeym (FACTS), local reports, and local GIS.

Fire Regime Condition Class. Developed in 2003, the fire regime condition class assessment system has provided a vital connection between managers understanding of fire regimes, ecological departure, and efforts to maintain sustainable landscapes (USDA, USDI 10-Year Comprehensive Strategy and Implementation Plans 2001–2002). Fire regime condition class classes reflect the current conditions degree of departure from two main components of ecosystem: (1) fire regime and (2) vegetation conditions (species composition, structural stage, stand age, canopy closure, mosaic pattern, and fuel composition are some examples) (Barrett et al. 2010). Managers use to document possible changes to key ecosystem components (Schmidt et al. 2002).

Fire regime condition class is another method to monitor and assess the current condition and in terms of this assessment, fire regime condition class has been calculated at two levels in order to portray conditions across the analysis area: (1) fire regime condition class has been calculated by the Francis Marion using localized fire history, vegetation treatments, vegetation conditions, and protocol established at the regional office in Atlanta; and (2) fire regime condition class has been calculated at the National Level in LANDFIRE as vegetation condition class (VCC).

Francis Marion-specific Fire Regime Condition Class. Figure 3-11 identifies the breakdown in fire regime condition class throughout the Francis Marion National Forest. The greatest number of acres with a fire regime condition class I departure lies within the core burn area. The core burn area represents an area where fire managers, for a number of reasons, have historically maintained prescribed fire on a very high frequency. Findings of the fire regime condition class analysis also support this core burn area spatial boundary.

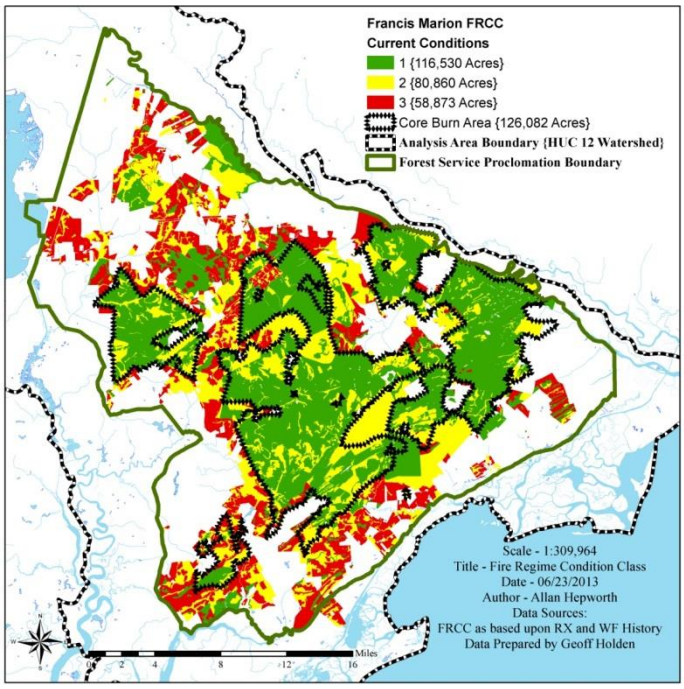


Figure 3-11. Francis Marion fire regime condition class

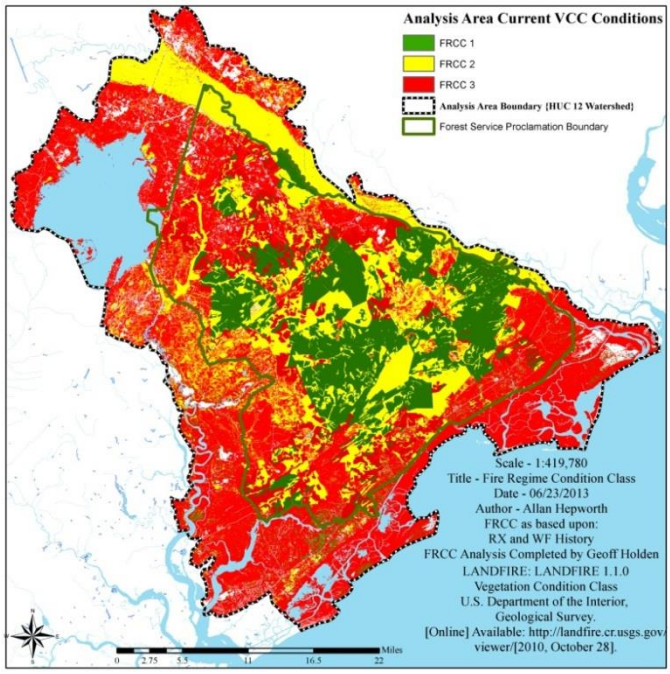


Figure 3-12. Analysis area current vegetation condition class conditions

Table 3-13. Francis Marion fire regime condition class breakdown

Francis Marion Fire Regime Condition Class		
Through 2012	**Acres**	**Total % of 259,345 Forest Owned Acres**
FRCC 1	116,530	45%
FRCC 2	80,860	31%
FRCC 3	58,873	23%
Unknown	3,081	1%

Analysis Area-Specific Fire Regime Condition Class. Figure 3-12 displays LANDFIRES version of fire regime condition class, vegetation condition class (VCC), from a regional perspective with the Francis Marion fire regime condition class overlaid. LANDFIRES VCC layer quantifies the amount that current vegetation has departed from the simulated historical vegetation reference conditions and holds the same fire regime condition class classifications of low (fire regime condition class 1), moderate (fire regime condition class 2), and high (fire regime condition class 3). VCC here is displayed for reference purposes only.

Creating Fire Adapted Human Communities

A large and rapidly expanding wildland-urban interface, driven by swiftly expanding population growth and urbanization, has added new complexities to both wildland fire suppression and prescribed fire operations.

The Southern U.S. is projected to experience the largest decline in forest area by 2060, losing about 17 million acres in one population growth scenario (Bowker et al. 2012). Total population growth within the eight counties that encompass and surround the analysis area increased by 60 percent from 1980 to 2010. Berkeley County alone observed a significant doubling of housing units between 1980 (31,771 units) and 2010 (65,367 units) (http://www.berkeleycountysc.gov/dept/planning/comp/). About 81 percent of the 812,000-acre analysis area can be defined as being wildland-urban interface lands potentially at very high risk of wildfire.

- Rapid population growth in the wildland-urban interface has become the chief cause of growing catastrophic fire loss and expenditures for combating wildfires (http://www.fs.fed.us/rm/pubs_other/rmrs_2000_cohen_j002.pdf).
    - A recent study by the Office of Inspector General (OIG) found that the majority of the Forest Service's fire suppression costs were related to protecting private property in the wildland-urban interface. According to Forest Service managers the estimated total cost of fighting large forest fires to protect private homes adjacent to Forest Service lands accounted for 50 to 95 percent of all costs, ranging from $547 million to $1 billion in 2003 and 2004 (OIG 2006).
    - "Wildland-urban interface per acre activity costs were estimated to be 139 percent higher than those of activities in non-wildland-urban interface areas (Berry et al. 2006)."
    - "For mechanical treatments, wildland-urban interface activity costs were estimated to be more than three times as much as for non-wildland-urban interface activities" (Berry and Hesseln 2004).

- "For fire treatments, wildland-urban interface per-acre activity costs were estimated to be 43 percent higher than those of non-wildland-urban interface activities" (Berry and Hesseln 2004).

- General risk complexities associated with wildland and prescribed fire operations are greatly heightened within the wildland-urban interface.
  - Structure fire suppression, which includes exterior and interior actions on burning structures, is the responsibility of state, tribal, county, or local fire departments (FSM 5137). Federal wildland fire agencies are not trained or authorized to suppress structure fires occurring in the wildland-urban interface.
  - Wildland and prescribed fire personnel also encounter hazards in the wildland-urban interface that are not typical to their profession and require additional mitigation measures:
    - *Hazardous materials:* Common chemicals used around the home may be a direct hazard to fire personnel from flammability, explosion potential and/or vapors or off-gassing. Such chemicals include paint, varnish, and other flammable liquids; fertilizer; pesticides; cleansers; aerosol cans; fireworks; batteries; and ammunition. In addition, some common household products such as plastics may give off very toxic fumes when they burn.
    - *Illicit Activities:* Marijuana plantations or drug production labs may be found in wildland urban interface areas. Extremely hazardous materials such as propane tanks and flammable/toxic chemicals may be encountered, as well as booby traps.
    - *Propane tanks:* Both large (household size) and small (gas grill size) liquefied propane gas (LPG) tanks can present hazards to fire personnel, including explosion.
    - *Utility lines:* Utility lines may be located above and below ground and may be cut or damaged by tools or equipment.
    - *Septic tanks and fields:* Below-ground structures may not be readily apparent and may not support the weight of engines or other apparatus.
    - *New construction materials:* Many new construction materials have comparatively low melting points and may "off-gas" extremely hazardous vapors. Plastic decking materials that resemble wood are becoming more common and may begin softening and losing structural strength at 180 °F, though they normally do not sustain combustion once direct flame is removed. However, if they continue to burn they exhibit the characteristics of flammable liquids.
    - *Pets and livestock:* Pets and livestock may be left when residents evacuate and will likely be highly stressed, making them more inclined to bite and kick.
    - *Evacuation occurring:* Fire personnel may be taking structural protection actions while evacuations of residents are occurring. Be very cautious of people driving erratically. Distraught residents may refuse to leave their property, and

firefighters may need to disengage from fighting fire to contact law enforcement officers for assistance. In most jurisdictions firefighters do not have the authority to force evacuations.

- *Limited access:* Narrow one-lane roads with no turn-around room, inadequate or poorly maintained bridges and culverts are frequently found in wildland-urban interface areas.

o Wildland and prescribed fire affects upon communities.

- Effects include increased anxiety because of the nearby fire, minor nuisances such as loss of visibility and ash fallout, temporary inconveniences such as disrupted or detoured traffic flow, and potentially serious public health and safety issues such as aggravation of respiratory ailments and reduction of roadway visibility.

Identifying Communities-at-risk and the Wildland-urban Interface within the Assessment Analysis Area

Background of Wildland-urban Interface. The Francis Marion National Forest, with its close proximity to Charleston and coastal beaches, has seen a substantial growth of commerce, industry, and tourism to the area, as well as further development of county and community infrastructure to support it. With this expanse, there is an increased risk of catastrophic wildfire to surrounding communities that abut the Francis Marion. This creates significant challenges to agencies in suppressing fires and implementing prescribed burning as a land management practice. Identifying communities-at-risk from wildfire and determining the wildland-urban interface or where people and human development meet and intermingle with wildland fuel (forests, range, etc.) allows for a further understanding of wildfire vulnerability and assessment of potential wildfire impacts. Furthermore, with clarifying the wildfire problem to communities and the wildland-urban interface, land managers and local government can address specific mitigation needs to further protect and safeguard communities and its infrastructure.

Federal Register Designation of Communities-at-risk. With congressional direction, an initial, Nationwide list of communities-at-risk from wildfires that are in the vicinity of Federal lands was compiled by the states and listed in the January 4, 2001, *Federal Register* (66:3). An updated and more expansive list of communities-at-risk was compiled in the August 17, 2001, *Federal Register* (66:160). Within this edition of the *Federal Register*, 60 communities were identified in the State of South Carolina, of which 12 communities fall within the proclamation boundary of the Francis Marion National Forest.

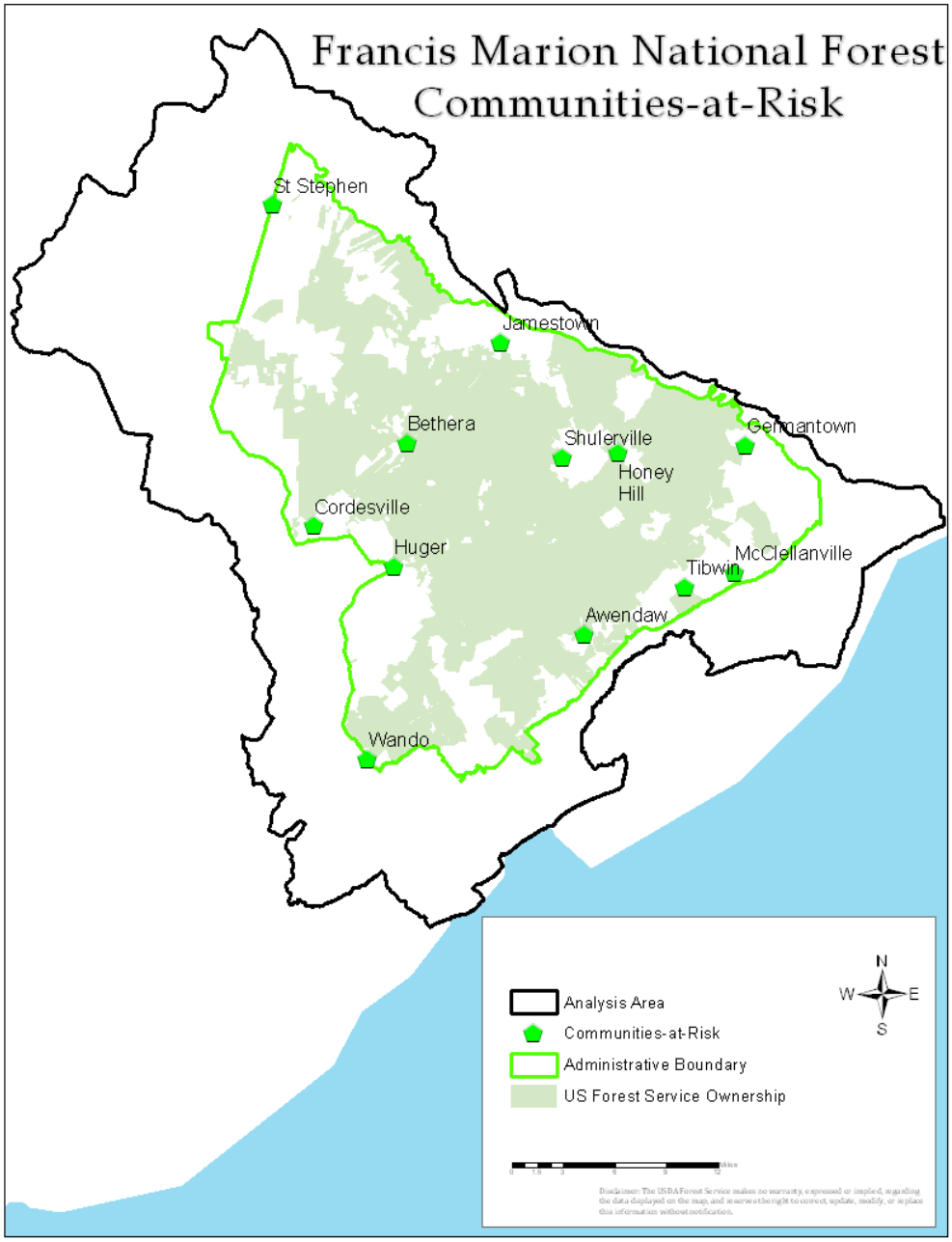


Figure 3-13. *Federal Register* communities-at-risk

Federal Register Designation of Wildland-urban Interface. In addition to identifying those communities-at-risk from wildfire, *Federal Register* 66:3 also provided a general definition of wildland-urban interface: "The Wildland Urban Interface is the area where houses meet or intermingle with undeveloped wildland vegetation". In addition to this rough definition, the *Federal Reg*ister also categorized three types of wildland-urban interface, identified with specific criteria relating to the location of structures to the wildland fuels, the number of structures per acre, and population densities. The three categories of wildland-urban interface are defined below:

> *Wildland-urban Interface:* The interface exists where structures directly abut wildland fuels. There is a clear line of demarcation between residential, business, and public structures and wildland fuels. The development density for an interface is usually three or more structures per acre. An alternative definition of the interface emphasizes a population density of 250 or more people per square mile.
>
> *Wildland-urban Intermix:* The intermix exists where structures are scattered throughout a wildland area. There is no clear line of demarcation: wildland fuels are continuous outside of and within the developed area. The development density in the intermix ranges from structures very close together to one structure per 40 acres. An alternative definition of intermix emphasizes a population density of between 28 to 250 people per square mile.
>
> *Occluded Wildland-urban Interface:* The occluded wildland-urban interface generally exists in a situation, often within a city where structures abut an island of wildland fuels. There is a clear line of demarcation between structures and wildland fuels and the development density is usually similar to those found in the interface, but the occluded area is usually less than 1,000 acres in size.

Mapping Federal Register Designated Wildland-urban Interface. With Federal financial support from the National Fire Plan, the University of Wisconsin SILVIS Lab was commissioned to collect spatial data and map the wildland-urban interface (intermix and interface only) across the entire U.S. Utilizing the parameters outlined in the *Federal Register*, the SILVIS lab collected intermix and interface wildland-urban interface data designed to provide a spatially detailed national assessment of the wildland-urban interface across the coterminous U.S. to support inquiries into the effects of housing growth on the environment, and to inform both national policy and local land management concerning the wildland-urban interface and associated issues.

Utilizing the SILVIS wildland-urban interface data, a further assessment was applied to the Francis Marion analysis area. The assessment revealed that the majority of wildland-urban interface identified was intermix or just over 87 percent of the overall total wildland-urban interface. About 73 percent of wildland-urban interface intermix was low-density-intermix type, where housing densities are fairly sparse, which would be expected for the broken ownership pattern of the Forest and its location to smaller but expanding communities. Table 3-14 and Figure 3-14 provides the amount and locations of the wildland-urban interface within the analysis area.

Table 3-14. Federal Register/SILVIS wildland-urban interface

SILVIS Wildland-urban Interface Type and Values	Map Legend Label	Acres of Wildland-urban Interface within Analysis Area	% of Wildland-urban Interface within Analysis Area (Acres)
High Density Interface: Housing density≥741.3162 and wildland vegetation≤50% and within 2.414 km of area with ≥wildland vegetation	Interface	1,094	0.70%
Medium Density Interface: Housing density between 49.42108 and 741.3162 and wildland vegetation ≤50% and within 2.414 km of area with ≥75% wildland vegetation	Interface	13,250	8.44%
Low Density Interface: Housing density between 6.177635 and 49.42108 and wildland vegetation ≤50% and within 2.414 km of area with ≥75% wildland vegetation	Interface	5,419	3.45%
High Density Intermix: Housing density ≥741.3162 and 2010 wildland vegetation >50%	Intermix	11	0.01%
Medium Density Intermix: Housing density between 49.42108 and 741.3162 and 2010 wildland vegetation >50%	Intermix	22,182	14.13%
Low Density Intermix: Housing density between 6.177635 and 49.42108 and 2010 wildland vegetation >50%	Intermix	114,979	73.27%
Total		**156,935**	**100.00%**

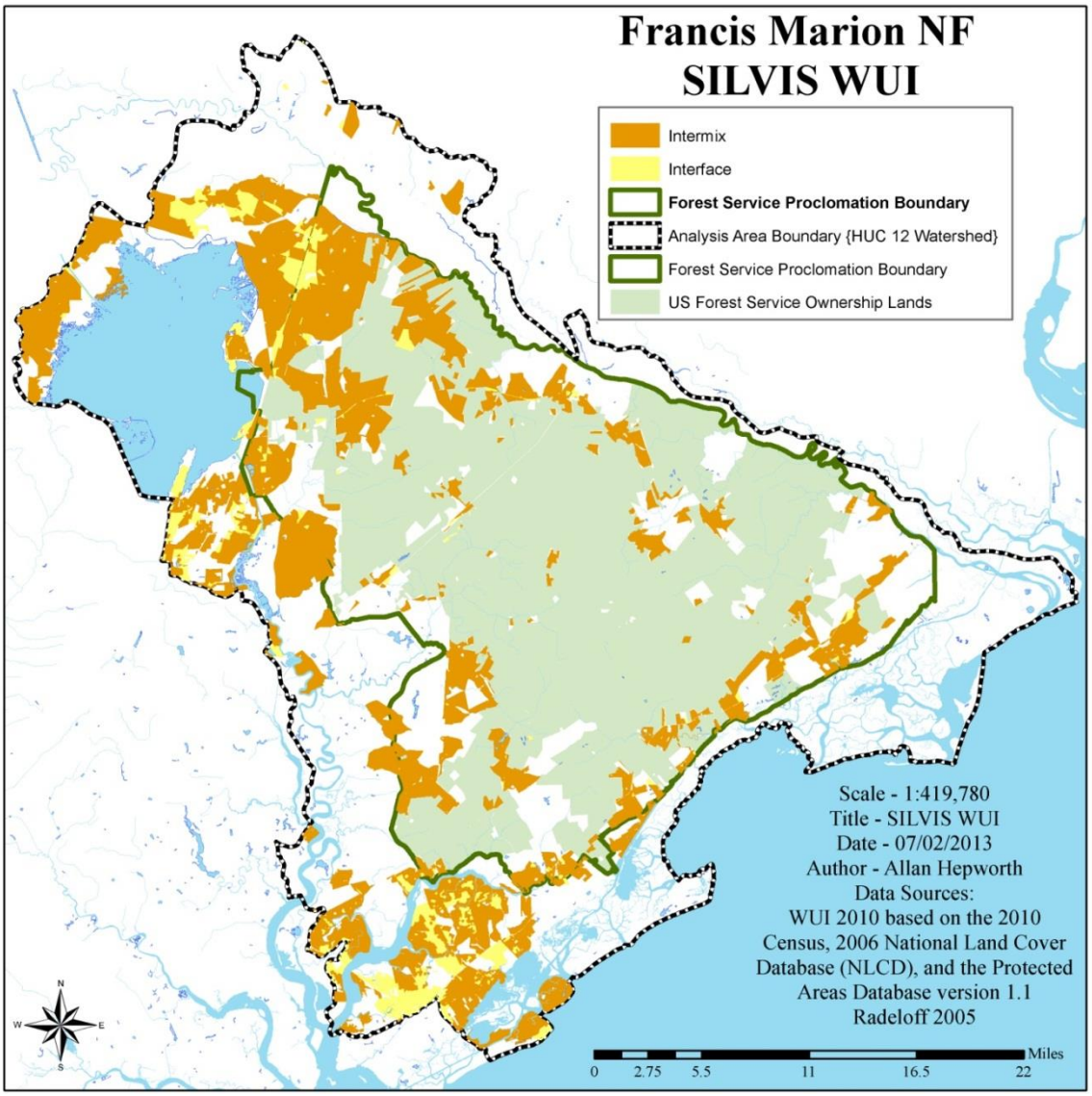


Figure 3-14. Federal Register/SILVIS wildland-urban interface

Healthy Forests Restoration Act Designation of Wildland-urban Interface. In December of 2003, the Healthy Forests Restoration Act (HFRA) was signed into law by President George Bush. Under this legislation, communities and local governments that are adjacent to Federal lands are authorized to develop community wildfire protection plans (CWPP) and by doing so, can develop their own wildland-urban interface designations and identify hazardous fuels treatments to be done within them. Without the absence of a CWPP, HFRA defines wildland-urban interface and sets specific limits to its designation which is described below:

(A) An area within or adjacent to an at-risk community that is identified to the secretary in a community wildfire protection plan: or

(B) In the case of any area for which a community wildfire protection plan is not in effect;

(i) An area extending ½-mile from the boundary of an at-risk community;

(ii) An area within 1½ miles of the boundary of an at-risk community, including any land that;

I. Has a sustained steep slope that creates the potential for wildfire behavior endangering the at-risk community;

II. Has a geographic feature that aids in creating an effective fire break, such as a road or ridge top; or

III. Is in condition 3, as documented by the secretary in the project-specific environmental analysis; and

(iii) An area that is adjacent to an evacuation route for an at-risk community that the secretary determines, in cooperation with the at-risk community, requires hazardous fuels reduction to provide safe evacuation from the at-risk community.

Mapping HFRA Designated Wildland-urban Interface. Utilizing HFRA criteria, a spatial analysis was conducted to establish a wildland-urban interface map of HFRA designated wildland-urban interface, to include a "buffering" distance of the established communities and wildland-urban interface (SILVIS) as well as major evacuation routes that would accommodate egress (class 4/5 roads). A 1.5-mile buffering distance from communities (wildland-urban interface) was used (the maximum HFRA allowance) due to the amount of fire regime condition class III in the vicinity of these areas, the shortened time frames of Coastal Plains fuel s to revert back to fire regime condition class III once treated, and the lack of natural or man man-made barriers to stop a fire under very high to extreme fire conditions and/or behavior. Using this analysis, roughly 78 percent of Francis Marion ownership fell within the wildland-urban interface and 74 percent of the analysis area was wildland-urban interface.

Class 4/5 "paved" roads were chosen as evacuation routes as they are consistent with the established hurricane evacuation routes for the area. Although evacuation route buffers under HFRA criteria can be limitless, a 1-mile buffering distance from evacuation routes class 4/5 roads (paved) was analyzed due to the increased numbers these roads within the analysis area. When analyzed, evacuation routes buffered by 1 mile indicated a wildland-urban interface coverage area of 71 percent of Forest ownership or roughly 56 percent of the analysis area. Table 3-15 and Figure 3-15 show the wildland-urban interface designation under specific HFRA criteria within the analysis area.

Table 3-15. HFRA designated wildland-urban interface

Feature	Type	Vicinity Buffer Distance (miles)	Acres on FS Ownership	% of Acres of FS Ownership	Acres in Analysis Area	% of Acres in Analysis Area
SILVIS Wildland-urban Interface	Wildland-urban intermix/interface	1.5	201,767	78%	603,246	74%
Evacuation Routes	Class 4/5 Roads	1.0	185,264	71%	456,824	56%
Combined Total with Overlap			227,255	88%	639,756	79%

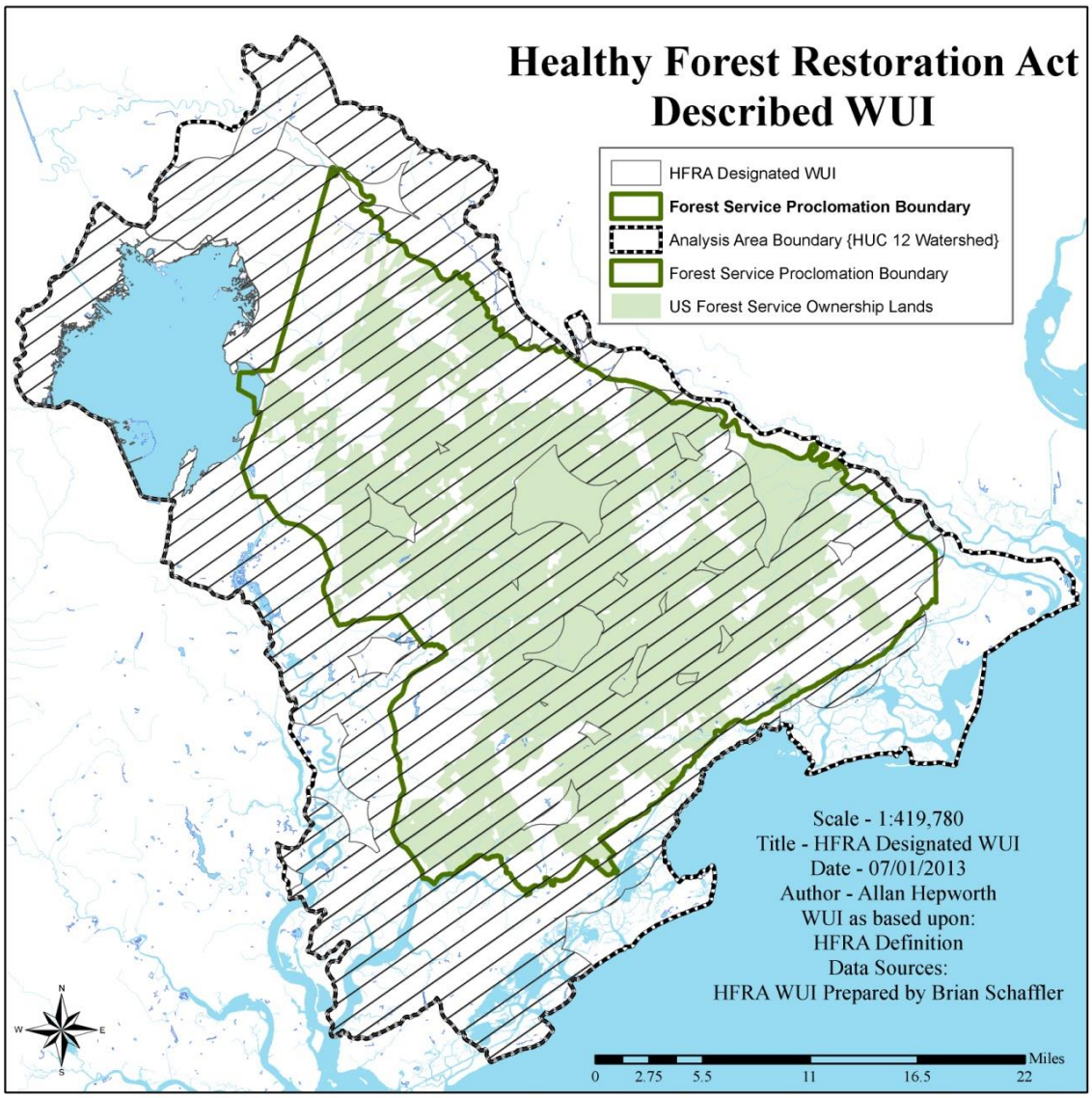


Figure 3-15. HFRA designated wildland-urban interface

Forest Values at Risk. In addition to assessing both *Federal Register* and HFRA wildland-urban interface within the analysis area, areas of public use and Forest infrastructure and/or capital improvements were also analyzed as wildland-urban interface utilizing a 1-mile buffer. The inclusion of on-Forest values-at-risk as wildland-urban interface is based is based on the prioritization of protecting life and property during suppression efforts and to promote focus on more intensive fuels treatments where they will have the most impact for fire protection on Forest lands. Table 3-16 and Figure 3-16 show the on-Forest values-at-risk wildland-urban interface designation utilizing a 1-mile buffering analysis.

Table 3-16. On-Forest values at risk wildland-urban interface designation

Feature	Type	Vicinity Buffer Distance (miles)	Acres on FS Ownership	% of Acres of FS Ownership	Acres in Analysis Area	% of Acres in Analysis Area
On-Forest Constructed Features	Buildings, bridges, dam	1	39,466	15%	49,244	6%
Recreation Sites	Campgrounds, trailheads, rifle ranges, wildlife viewing sites, etc.	1	33,437	13%	55,490	7%
Trails	Horse, cycle, hiking	1	101,854	39%	143,292	18%
Combined Total with Overlap			**118,356**	**46%**	**170,457**	**21%**

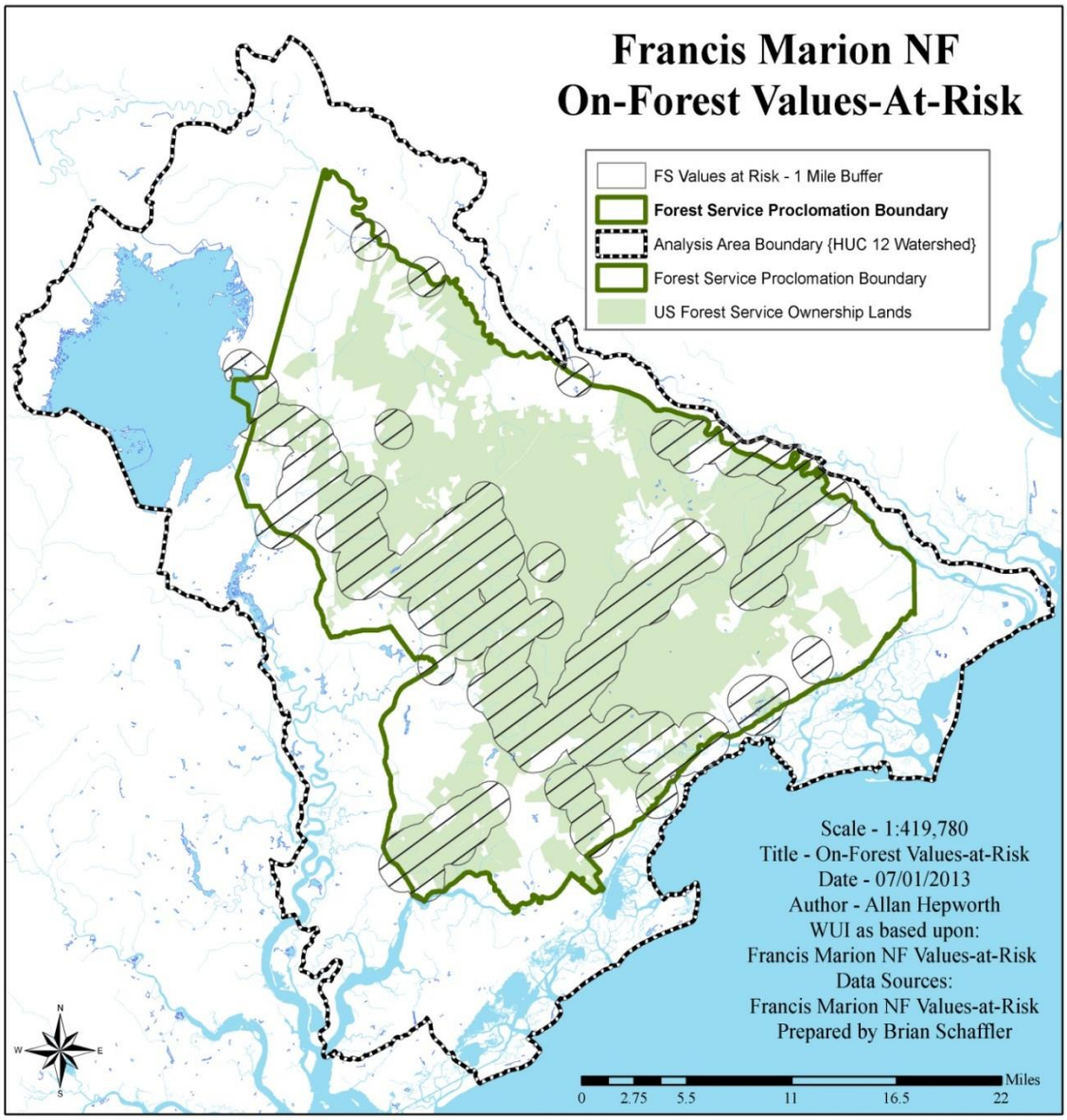


Figure 3-16. On-Forest values-at-risk wildland-urban interface

Combined Wildland-urban Interface: HFRA and On-Forest Values-at-Risk. For the purposes of the Francis Marion Plan Assessment, a combined wildland-urban interface area was refined to a buffer around numerous wildland-urban interface values in order to capture the full extent of human influence and potential wildfire impact under critical fire conditions. With this analysis, two wildland-urban interface data sets, to include HFRA designated wildland-urban interface and on-Forest values-at-risk wildland-urban interface, were merged to create a total combined wildland-urban interface data set and accompanying map. When concluded, the combined wildland-urban interface totaled over 650,000 acres within the analysis area or almost 81 percent. The combined wildland-urban interface is shown in Table 3-17 and Figure 3-17.

Table 3-17. Combined wildland-urban interface

Feature	Type	Vicinity Buffer Distance (miles)	Acres on FS Ownership	% of Acres of FS Ownership	Acres in Analysis Area	% of Acres in Analysis Area
SILVIS Wildland-urban Interface	Wildland-urban intermix/interface	1.5	201,767	78%	603,246	74%
Escape Routes	Class 4/5 roads	1	185,264	71%	456,824	56%
On-Forest Constructed Features	Buildings, bridges, dam	1	39,466	15%	49,244	6%
Recreation Sites	Campgrounds, trailheads, rifle ranges, wildlife viewing sites, etc.	1	33,437	13%	55,490	7%
Trails	Horse, cycle, hiking	1	101,854	39%	143,292	18%
Combined Total with Overlap			239,733	92%	654,585	81%

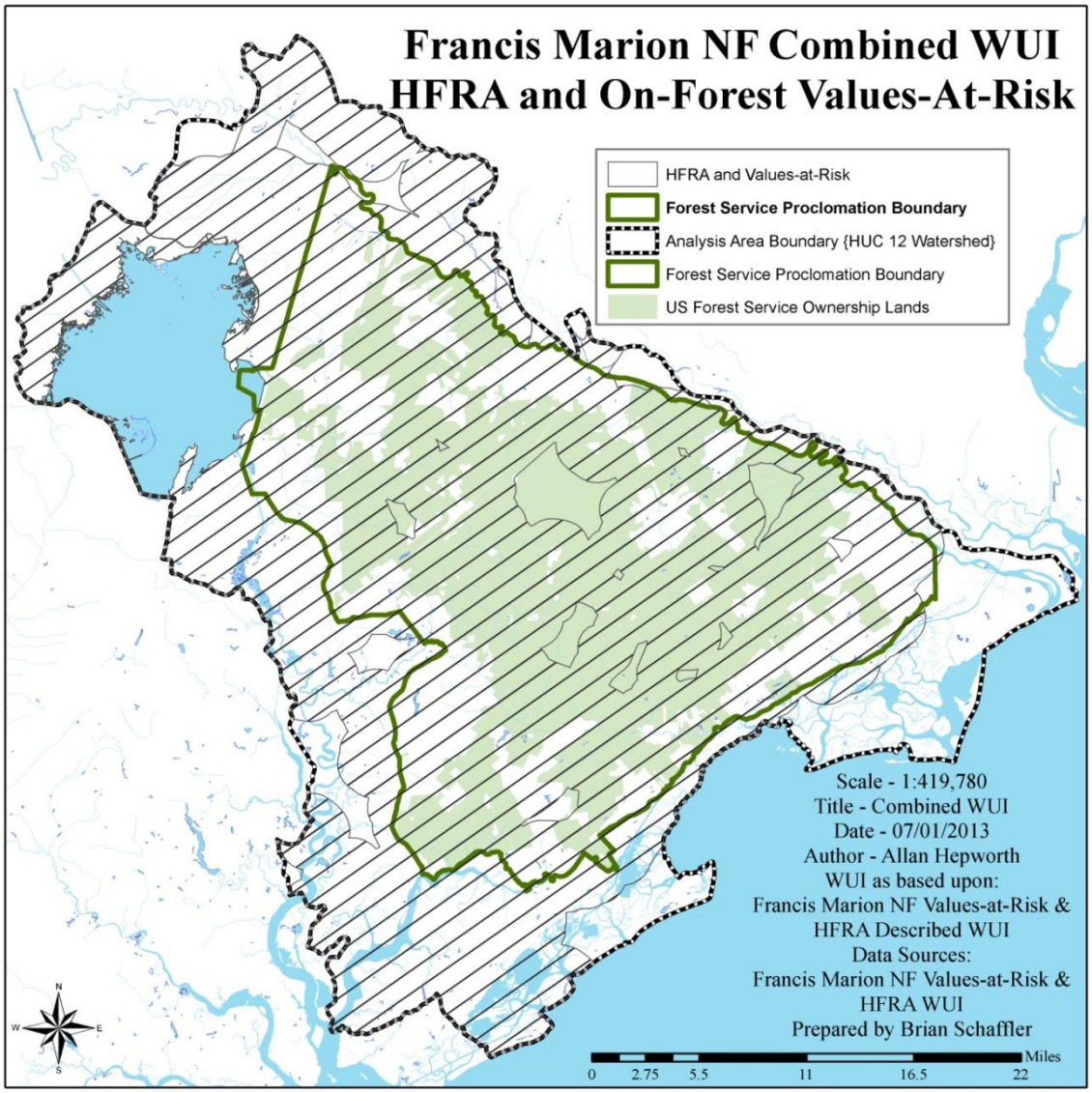


Figure 3-17. Combined wildland-urban interface

Community Wildfire Protection Plan. A CWPP, as authorized by the Healthy Forest Restoration Act of 2003, is a plan for an at-risk community that (A) is created and agreed upon by applicable local governments, fire departments, state agency, and Federal land management agencies; (B) identifies priorities for hazardous fuel reduction treatments and recommends types and methods of treatment; and (C) recommends measures to reduce structural ignitability throughout the at-risk community.

The goal of fire managers on the Francis Marion is to have all Forest-owned lands covered by CWPPs.

The Awendaw Consolidated Fire District CWPP is a great example of proactive stakeholder involvement in identifying the potential problems associated with wildland-urban interface and addressing those actions that can be taken to mitigate them. The Awendaw CWPP encompasses a total of 144,431 acres of mixed ownership lands.

Fuels Treatments. Between the years 2005 and 2012 over 127,000 acres of hazardous fuels build-up were treated with prescribed fire in the wildland-urban interface. Figure 3-18 illustrates this prescribed fire breakdown; the hatched area represents Forest Service lands impacted by wildland-urban interface; the red fill represents areas burned; and the red fill overlaid with hatch represents areas where prescribed burning has occurred within the wildland-urban interface.

Mechanical Treatment. Another effective tool in reducing hazardous fuels buildup is implemented mechanically with two general types: (1) by rearranging biomass and leaving on site; and (2) by removing biomass from the site.

Figure 3-19 highlights mechanical treatments of all types on the Forest from 2005 to 2012. For reference, wildland-urban interface defined lands are overlaid. It should be noted here that the mechanical treatments described on the map do not necessarily have hazardous fuels reduction as a priority objective, but are being assessed regardless as they can support hazardous fuels reduction objectives.

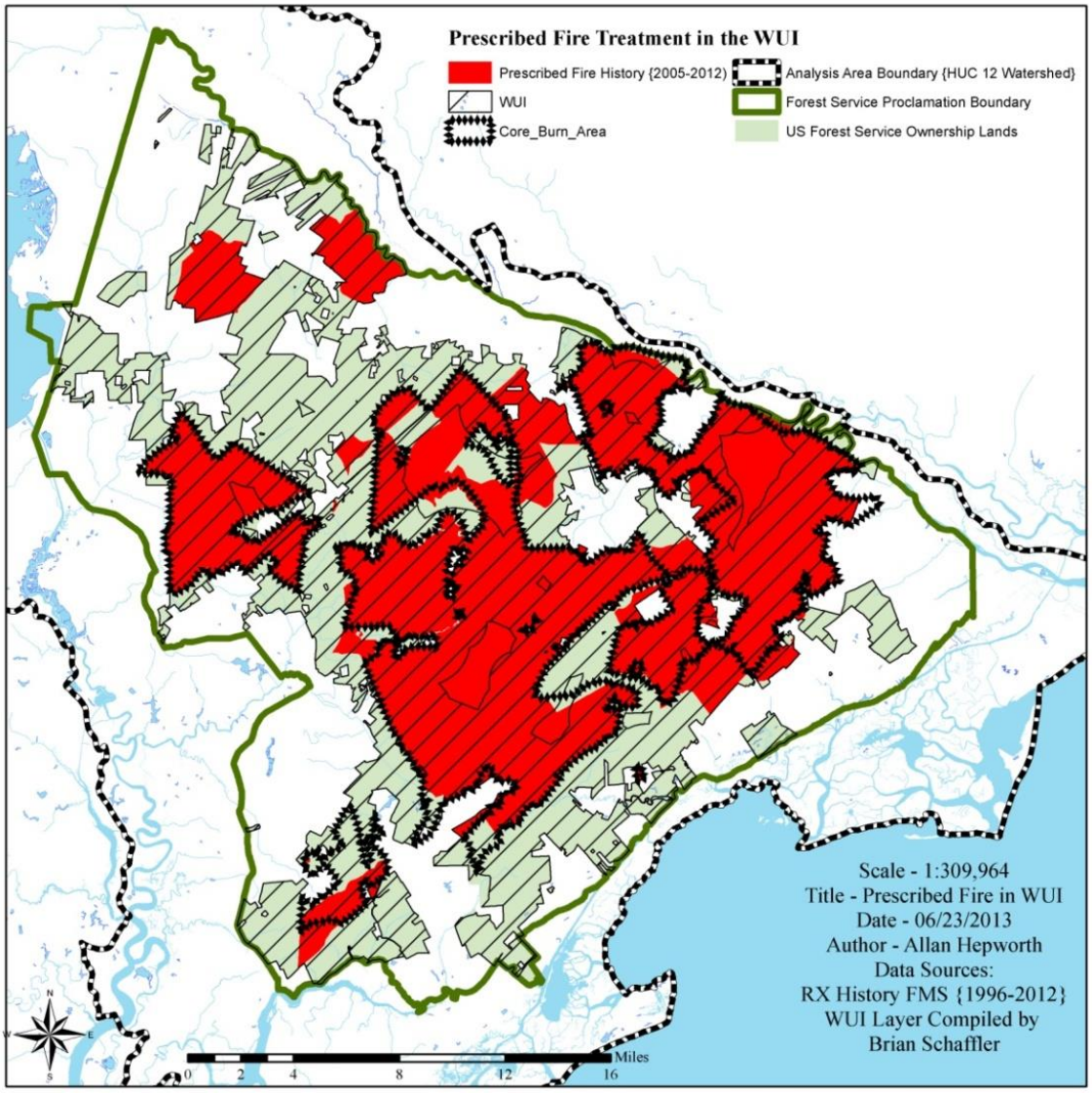


Figure 3-18. Prescribed fire treatment in the wildland-urban interface

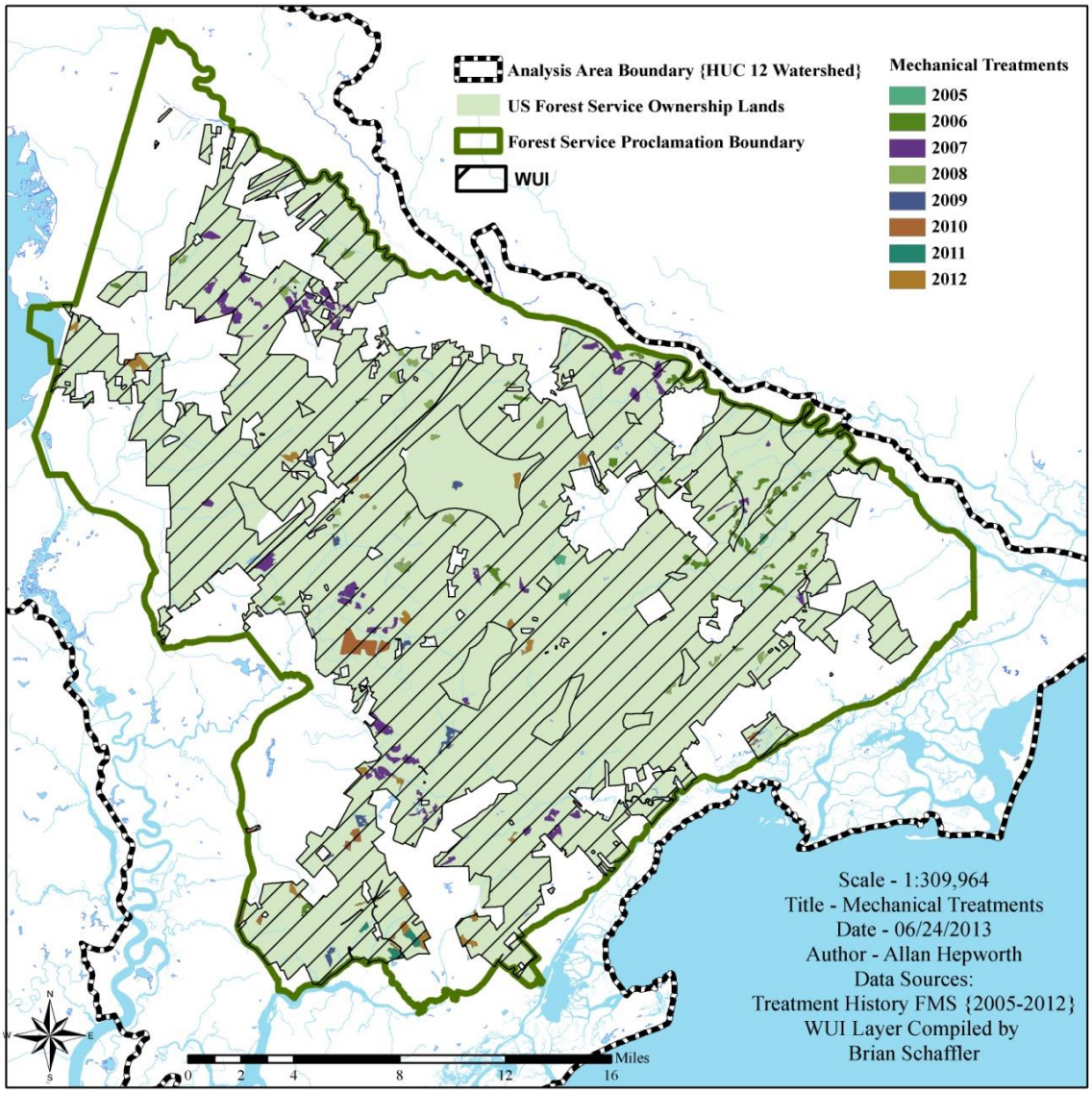


Figure 3-19. Mechanical treatments

Table 3-18. Mechanically treated acreage breakdown, 2005 to 2012

Mechanical Activity	Acres Accomplished
Commercial Thinning	2,063
Area Release and Weeding	2,000
Precommercial Thinning	54
Wildlife Habitat Thinning	1,718

Common hindrances to effectively implementing mechanical treatment (Marshall et al. 2008):

- Vegetation types in the Southern U.S. re-sprout rapidly and vigorously after mechanical treatment.
- Wet soils and seasonal wetlands can limit access for equipment.
- Mechanical treatment is relatively expensive compared to prescribed burning.

Grazing. Another practical option for reducing and maintaining hazardous fuel loading, specifically in the wildland-urban interface where prescribed fire utilization becomes more difficult, is managed livestock grazing. Goals and objectives in the 1996 Forest plan provide guidance; however, this option has not been implemented as a specific hazardous fuels reduction objective since 1996. Techniques referred to as targeted grazing or prescribed grazing may be used to mimic natural disturbances such as wildfire in such areas.

Effectively Responding to Wildfire

Wildland fire management in the Coastal Plain of South Carolina is a complex, multi-faceted and continual process. The potential exists for significant threat of unplanned or undesirable wildfire to the lives and well-being of emergency responders and the public throughout all 12 months of the year. Fire managers also understand the significant role that fire has as a necessary system driver and are constantly faced with the challenges of managing fire for its benefit. Agencies tasked with wildland fire management within the analysis area are comprised of a number of different agencies and municipalities, each of which adheres to agency-specific goals and objectives.

As shown in Figure 3-20, fire ignitions are common across the analysis area landscape. The following figures and tables will provide general findings of unplanned fire occurrence in the analysis area. To further assess resource response effectiveness, fire danger, and potential fire behavior, the assessment, following the general occurrence observations, will further analyze historical fire occurrence findings along with fire weather conditions in hopes of isolating potential problem fires.

Figure 3-20 offers some additional perspective relating to unplanned fire occurrence within the analysis area. Fires can and do occur throughout the calendar year; however, the months of February through April typically see peak occurrence. The majority (62 percent) of fires are suppressed at less than 10 acres in size, with 71 percent of fires being suppressed in 2 days or less. Less than 2 percent of all unplanned fires in the analysis area have historically surpassed size class C. It is also interesting to note that 11 percent of all unplanned ignitions within the State of South Carolina occur within the analysis area, which makes up 4 percent of the State's land mass.

Table 3-19 shows the percentage of wildland fires having occurred from 1992 to 2012 in the analysis area as compared to South Carolina. One observation discovered in this analysis is that 35 percent of both F and G size class fires occurring in South Carolina have occurred in the analysis area; 75 percent of these large fires having occurred on the Francis Marion. It is also observed that fire sizes remain relative throughout the State until exceeding 10 acres; at 10 acres the amount of fire occurrence within the analysis area relative to the State continues to grow through size class.

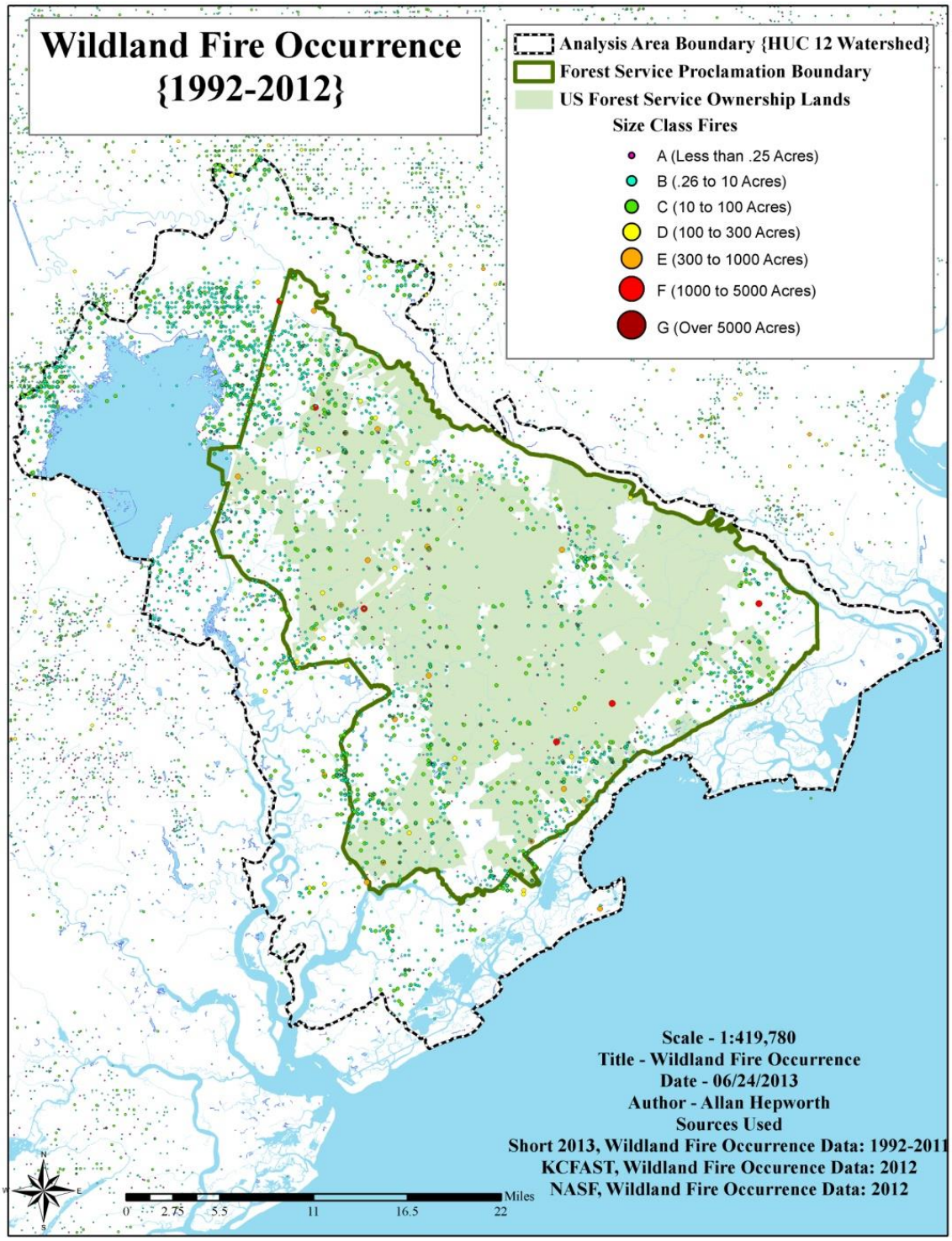


Figure 3-20. Wildland fire occurrence map

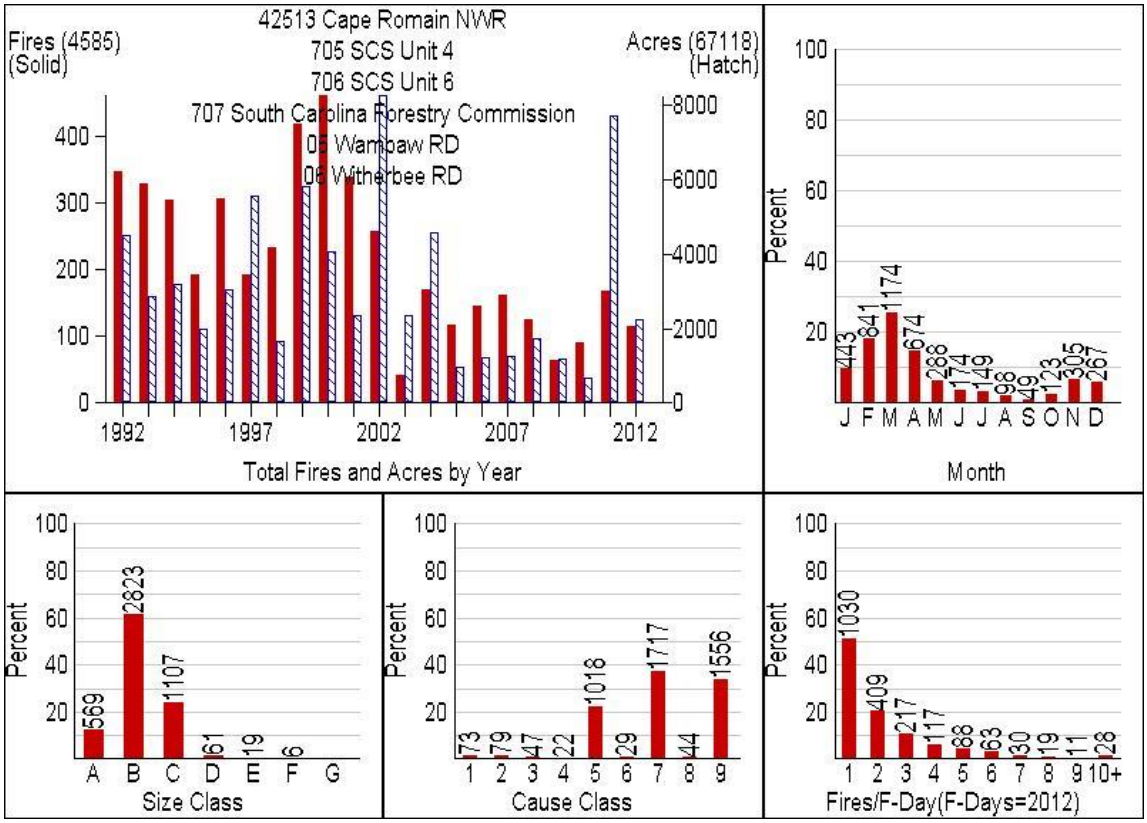


Figure 3-21. Analysis area wildfire summary

Table 3-19. Analysis area fire statistics relative to the State of South Carolina (1992–2012 Fires)

				Francis Marion N.F		
	South Carolina	Analysis Area	% of South Carolina	Proclamation Boundary	% of Analysis Area	% of State
Total Land Area (Acres)	19,798,768	812,733	4%	416,640	51%	2%
Total Fires	75,852	4,585	6%	1,275	28%	2%
Size Class A Fires (<0.25 ac)	12,842	569	4%	241	42%	2%
Size Class B Fires (0.25–10 ac)	52,466	2,823	5%	670	24%	1%
Size Class C Fires (10–100 ac)	10,024	1,107	11%	316	29%	3%
Size Class D Fires (100–300 ac)	425	60	14%	30	50%	7%
Size Class E Fires (300–1,000 ac)	78	20	26%	15	75%	19%
Size Class F-G Fires (1,000 ac+)	17	6	35%	4	66%	24%
Fires per Square Mile	2.45	3.60		1.9		

Historical Fire Occurrence on the Francis Marion National Forest

Between 1970 and 2012, there were 3,029 fires on the Francis Marion which burned a total of 60,475 acres (Figure 3-22). The largest fire during this period was 2,765 acres and occurred on March 31, 1997. The four largest fires on the Forest have occurred since 2003. Fires can occur in all months but "fire season" is generally considered November through May with peak burning conditions mimicking those of the surrounding analysis area. Periods of drought accompanied during the summer months can extend fire season into the summer.

Fire Danger and Fire Probability Analyses

In order to assess resource effectiveness and potential fire danger and probability across the analysis area, the following analyses have been completed. Three primary RAWS (remote automated weather stations) (Figure 3-23) were used in the analysis to capture broad-scale weather patterns and trends.

- Witherbee RAWS (WIMS ID 384002) data for the years of 1992–2012
  - Weighted 1.0
- Santee NWR RAWS (WIMS ID 383401) data for the years of 1996–2012
  - Weighted 0.5 due to minimal data years
- Ace Basin RAWS (WIMS ID 384101 data for the years of 2010 –2012
- Weighted 0.25 due to minimal data years

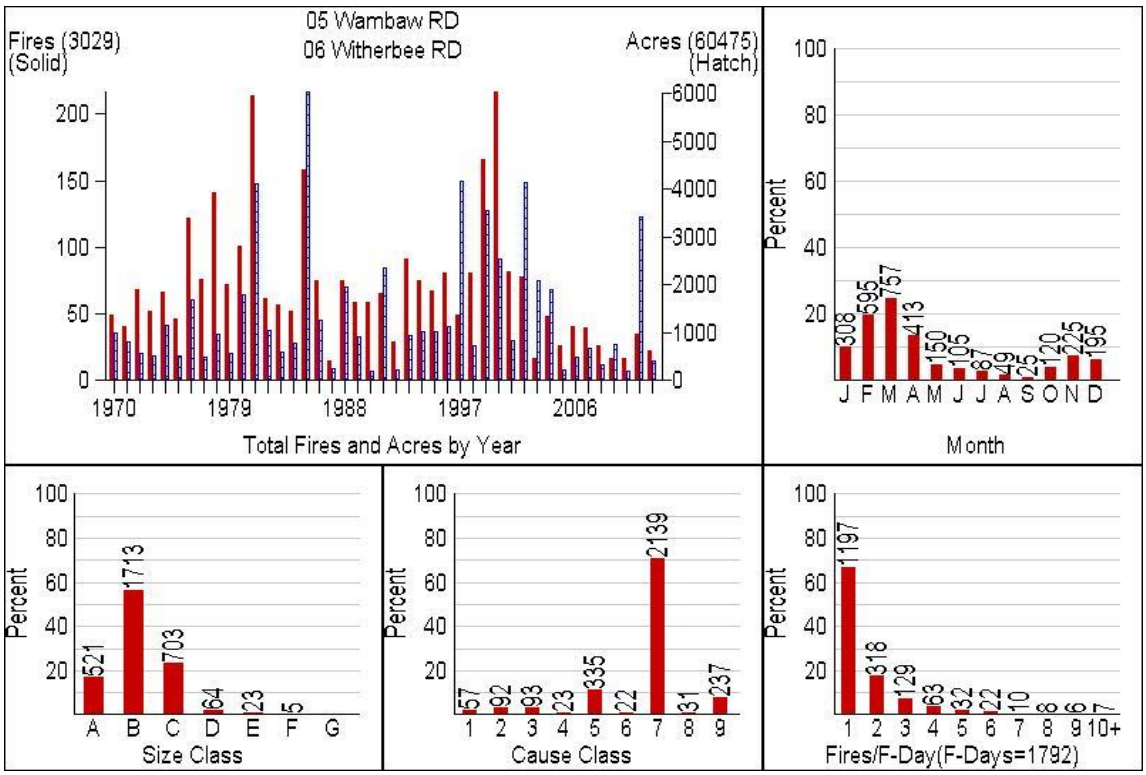


Figure 3-22. Francis Marion wildfire summary

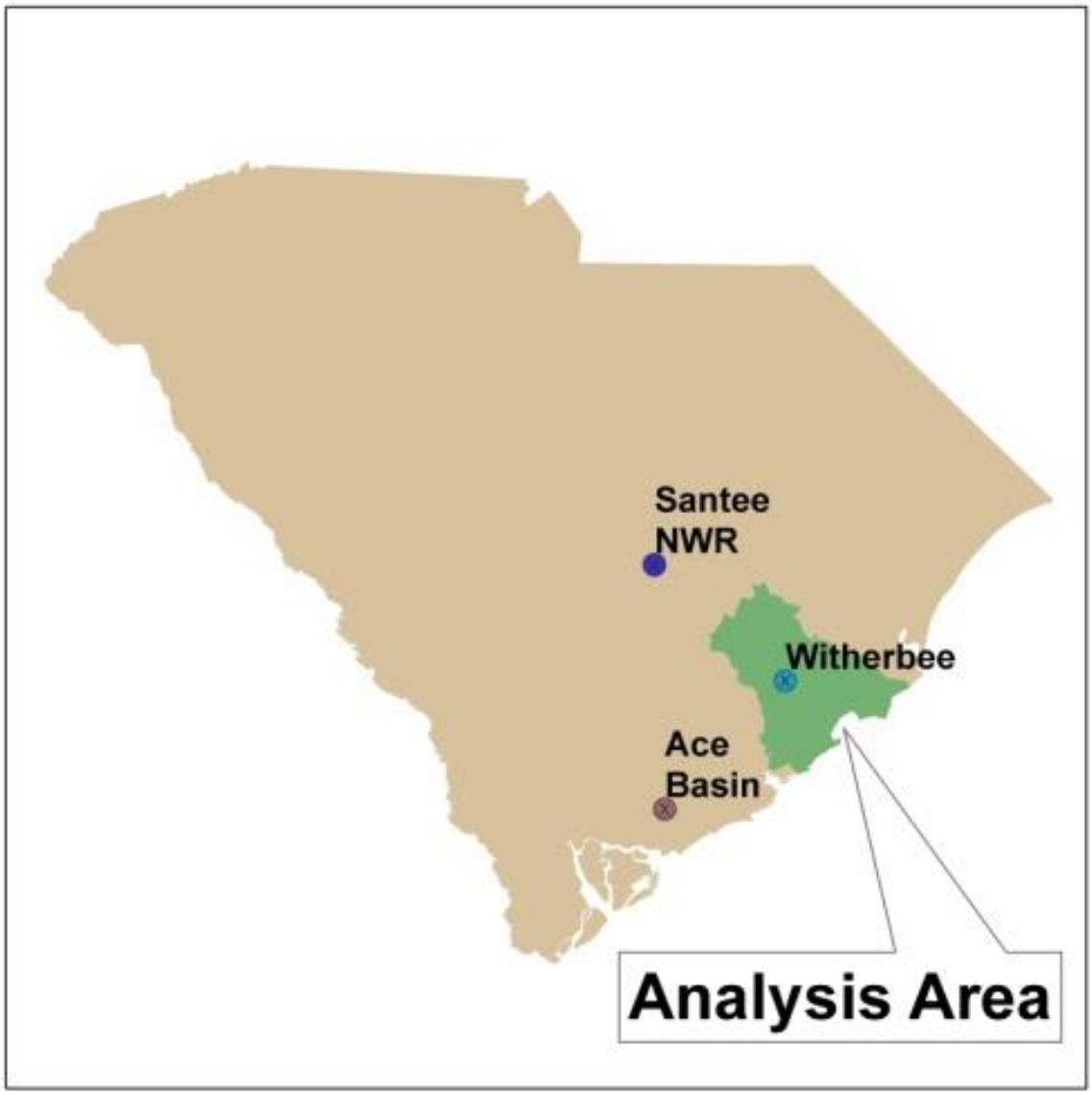


Figure 3-23. Analysis area remote automated weather stations

Analysis Tools Used: There are many ways to characterize fire danger and attempt to predict potential fire behavior.

In order to analyze fire danger and fire behavior, several data sets and modeling software programs have been used.

- FireFamilyPlus (FFP) is a Windows program that combines fire climatology and fire occurrence analysis. FFP was used here to organize weather data from RAWS and fire occurrence data for export into the BehavePlus and ArcGIS programs.
- LANDFIRE (also known as Landscape Fire and Resource Management Planning Tool) is an interagency vegetation, fire and fuel characteristics mapping program that provides a national interagency database of spatial coverage for reference, in this case, for forested lands outside the Forest boundary and within the analysis area.

- BehavePlus is a PC-based program that is a collection of models that describe fire and the fire environment. It is a flexible system that produces tables and graphs and can be used for a multitude of applications.
    - The primary modeling capabilities of BehavePlus as used for this assessment include surface fire spread and intensity.
- FlamMap is a fire behavior prediction and assessment model that is widely used across the Nation and in many other countries. It was produced by Dr. Mark Finney of the Missoula Fire Lab in 2006. FlamMap here will be used to assess fire type.

Uncertainties: It is important to keep in mind that there are known and unknown uncertainties when attempting to model potential fire behavior.

- Potential fire behavior was modeled using daily observations of historical weather. The required inputs to BehavePlus (wind speed, 1-Hour, 10-Hour, 100-Hour, live and woody fuel moistures) are all extremely variable. Best efforts have been made to model potential fire behavior here using scenarios that truly represent the analysis area fire environment under moderate to extreme moisture conditions. Modeling fire behavior as a fire danger indicator is impossible and the intent here is to simply provide a general estimate of potential conditions.
- LANDFIRE spatial data is extracted from national coverage data sets. The datasets are being continually updated and provide the best available comprehensive and standardized Nationwide data set.

Fire Danger.

FFP Pocket Card Analysis: Historically the Fire Danger Pocket Card is a tool based on the Nation Fire Danger Rating System (NFDRS) to help firefighters develop an awareness of current fire situations. The pocket card concept is advantageous here as it provides general indicators of fire spread potential and difficulty of control. In terms of this assessment, this pocket card analysis has been created and included to offer observations of past fire history coupled with the NFDRS index Burning Index.

The two NFDRS indices used are:

Burning Index (BI) gives day-to-day fluctuations calculated from 2 p.m. temperature, humidity, wind, daily temperature and relative humidity ranges, and precipitation duration. Wind is part of the BI calculation.

Energy Release Component (ERC) gives seasonal trends calculated from 2 p.m. temperature, humidity, daily temperature and relative humidity ranges, and precipitation duration. Wind is not part of ERC calculation. ERC can serve as a good characterization of fire season as it tracks seasonal fire danger trends. ERC is a function of the fuel model and live and dead fuel moistures.

Using BI and ERC and then combining local knowledge and FFP, the following pocket cards were created.

Although several fuel models exist within the analysis area, Fuel Model D (Southern Rough) was used in the analysis.

The NFDRS definition of Fuel Model D is: This fuel model is specifically for the palmetto-gallberry understory-pine overstory association of the Southeast Coastal Plains. It can be also

used for the so-called “low pocosins” where Fuel Model O might be too severe. This model should only be used in the Southeast because of high moisture of extinction (http://www.fs.fed.us/fire/planning/nist/nfdr.htm).

Figure 3-24 is the pocket card produced for the analysis area using 21 years of weather and fire date. Years 2002 and 2011 were selected to remember by using the findings in Figure 3-21. These two years were selected because they offer good perspective to recent years in which increased amounts of acres were burned. Also included on the pocket card are four historic large fires and the indices fire personnel experienced during the events. On March 23, 2011, the South Carolina Forestry Commission and Francis Marion experienced simultaneous large fires. Noted on the pocket card, the Wind and Rifle fires burned a combined 4,300 acres within three burn periods. Local thresholds used to determine “Watch-Out” factors had been defined by fire managers previously. We may look here at these factors and test there validity.

Table 3-20 offers additional observations of wildland fires occurring on the same day as the pocket card fires listed above.

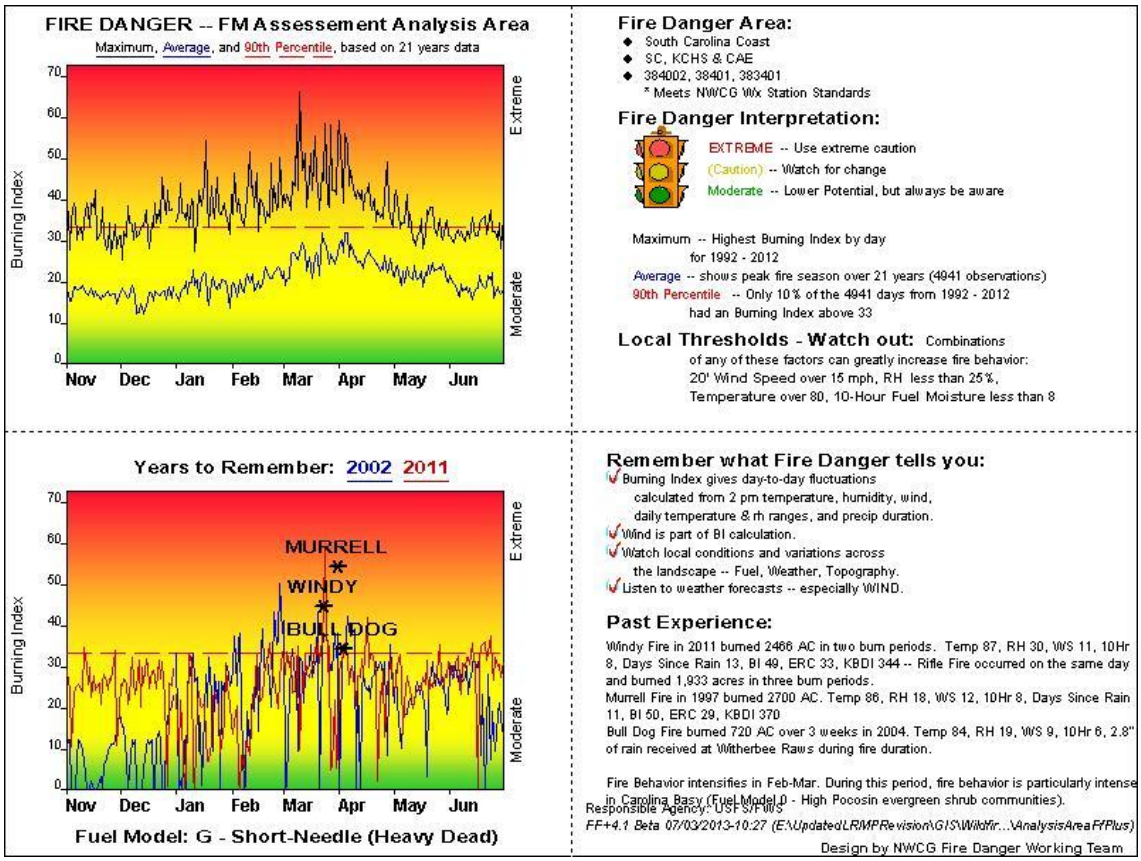


Figure 3-24. Analysis area NFDRS pocket cards

Table 3-20. Additional pocket card-specific statistics

Fire Name	Number of Other Analysis Area Fires	Total Analysis Area Acres Burned
Murrell	8	2,936.5
Bull Dog	4	729.2
Windy	6	4437
Rifle	6	4437

Fire Weather Indices Analysis: Attempting to categorize weather thresholds that, when combined, can greatly increase fire behavior is difficult. The quickest way to isolate general weather indices which have historically been conducive to fire spread and control difficulties is to compare historic weather events to wildfire events and then fine-tune by narrowing down final fire size and fire spread duration. As observed previously in Table 3-19, less than 2 percent of wildland fire ignitions exceed 100 acres in size. For this analysis we will highlight the overall trend in indices through size class and then isolate specific indices for the fires exceeding 100 acres. Another very important variable is fire duration. A fire burning 300 acres over the course of three weeks does not tell us as much as a fire burning 300 acres in a day. Fires that escape initial attack and burn into the second burn period are perhaps the most telling (what variables aligned to support this). It is also important to note that this process is based upon past records; some records may be extremely accurate and some may not.

Figure 3-25 highlights the mean weather index value per size class. It is observed that through size class fire A to F the trend of each individual weather index moves towards values more conducive to fire spread. For reference purposes Table 3-21 quickly highlights the number of fires again in each size class.

Table 3-21. Number of fires per size class

A	B	C	D	E	F
569	2,823	1,107	61	19	6

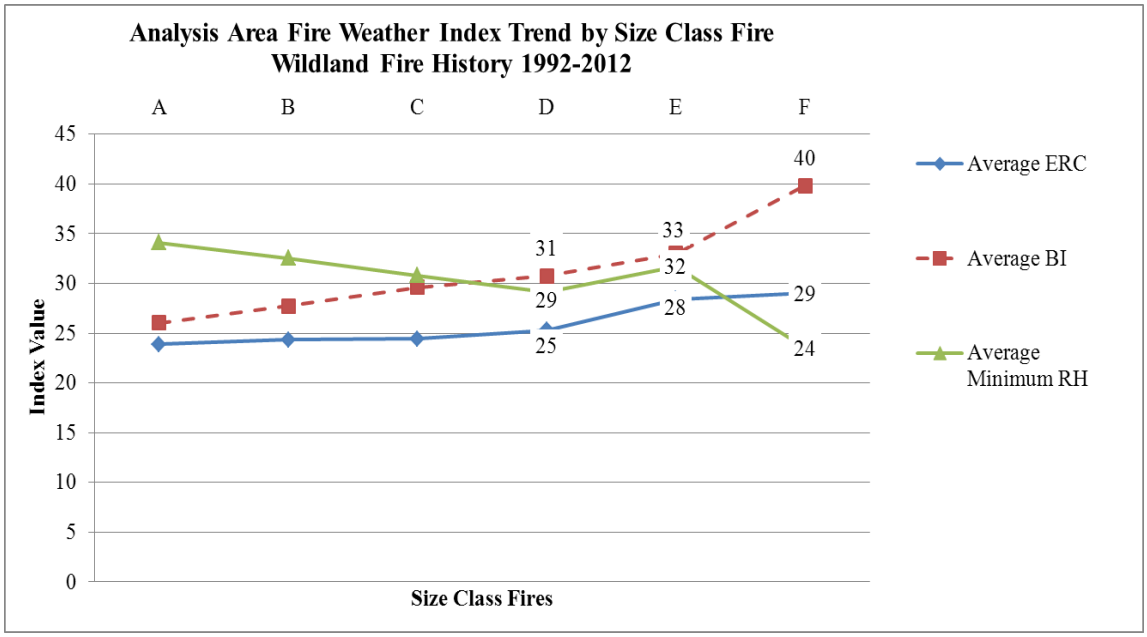


Figure 3-25. Weather index trend through size class fire

Note: Size Class A=0.0 to 0.25 ac; B=0.26 to 9.9 ac; C=10.0 to 99.9 ac; D=100.0 to 299.9 ac; E=300.0 to 999.9 ac.

As observed earlier and supported by the findings here in Table 3-22, isolating and combining common thresholds that support large fire growth is a difficult task. Per Figure 3-25 above a simple analysis can be completed here in order to substantiate local thresholds which have been used historically.

Table 3-22. Analysis area weather indices per large fire events

Fire Name	Acres	Max T	Min RH	Wind Speed	10 Hr Fuel Moisture	BI	KBDI	ERC	Duration (Burn Periods)	Days Since Rain
Big Ocean	100	81	1	17	11	59	72	22	3	4
*Unknown	100	83	1	8	10	42	91	25	1	5
*Unknown	100	70	22	12	8	52	90	35	1	10
*Unknown	175	55	24	4	10	22	163	18	1	4
USFS SCFC	100	84	31	6	7	37	287	31	1	8
Universal Circle	250	99	35	6	7	32	651	38	1	4
*Unknown	197	101	39	5	7	31	678	40	3	7
*Unknown	125	77	41	10	13	34	121	18	1	3
Valley Wood	102.7	78	42	5	9	30	192	27	1	15
Sawmill Road	148	75	42	7	8	38	208	32	3	8
*Unknown	118.8	60	43	12	10	47	529	30	2	20
*Unknown	100	73	49	8	12	18	503	12	1	10
*Unknown	150	82	50	17	22	30	350	15	1	20
Size Class D Range		55–101	1–50	4–17	7–22	18–59	72–678	12–40	1–3	3–20
Size Class D Averages		78	32	9	10	36	302	26		9
Moe	305	81	39	11	13	36	241	22	1	20
Wedboo	325	94	37	7	9	31	636	34	3	2
*Unknown	475	98	51	7	10	29	498	28	1	1
Size Class E Range		81–98	37–51	7–11	9–13	29–36	241–636	22–34	1–3	1–20
Size Class E Averages		91	42	8	10	32	458	28		8
Rifle	1,933	87	30	11	8	49	344	33	3	13
Windy	2,466	87	30	11	8	49	344	33	2	13
Size Class F Range									2–3	
Size Class F Averages		87	30	11	8	49	344	33		13

Current Pocket Card Local Thresholds:

Table 3-23. Current pocket card thresholds

Temperature	Over 80	Relative Humidity	Less Than 25
20’ Wind Speed	Over 15	10-Hour Fuel Moisture	Less Than 8

Pocket Card Threshold Analysis Findings:

- The over 80 degree threshold is consistent with historical records.
- The less than 25 percent threshold may be a little lower than historical records. Table 3-22 isolated wildfire events having greater size in less burn periods (less than 3). The resulting relative humidity average values are greater than the 25 previously used on pocket cards. Findings here have shown that relative humiditys as low as 30 when

combined with other factors could heighten fire behavior. It should also be noted here that when averaging all size class D–F, the average relative humidity is 26 percent.

- The over 15 miles per hour (mph) wind speed threshold also may be under estimating. The historic average wind speed of all size class D–F fires is less than 9 mph and when breaking these averages down to those fires with very short burn period duration (1–3 days), the averages are consistently 9 mph.
- Ten-hour fuel moisture thresholds historically used on pocket cards are fairly consistent with those observed during the past 21 years on significant events.

Fire Behavior: Again, there are several technological processes fire analysts use to calculate and/or model potential fire behavior in order to preplan and prepare for an unplanned wildland fire event. All of these processes, or models, rely on inputs that are based upon past, current, and forecasted observations (weather and fuels conditions) and the best available data relating to topography and fuel type. The ability to model and predict fire behavior using past and forecasted observation is especially difficult as the combinations of weather and fuels conditions can vary from minute to minute throughout the day and when combined with topographical influence, conditions can change rapidly across the landscape. We have used what we feel are the best available sciences to assess current conditions, or potential fire behavior, using four weather and fuel scenarios.

Here, we have focused on key elements of potential fire behavior that are most important in both their influence on ecosystem integrity and humans, and our ability to influence them. These include: intensity and spread rate (difficulty in management or suppression and how fast it moves); and severity or fire type (surface, mixed or moderate, crown).

Intensity: Intensity refers to how hot a fire burns (Pyne et al. 1996).

Flame length is the length of a flame from the base to the tip. Fire managers use several basic categories (Table 3-24) to decide whether a fire can be suppressed or managed with handtools, heavy equipment (e.g., bulldozers), aircraft, or indirectly from a safe distance (page 64, Pyne et al. 1966).

Table 3-24. Hauling chart: Tactical interpretations from flame length

Flame Length	Interpretations
Less than 4’	Fires can generally be attacked at the head or flanks by firefighters using hand tools. Handlines should hold the fire.
4’ to 8‘	Fires are too intense for direct attack on the head with hand tools. Handline cannot be relied on to hold the fire. Dozers, tractor-plows, engines and retardant drops can be effective.
8’ to 11’	Fire may present serious control problems: torching, crowning, and spotting. Control efforts at the head will probably be ineffective.
Over 11’	Crowning, spotting, and major fire runs are probable. Control efforts at the head of the fire are ineffective.

Table 3-25. Scott and Burgan adjective class definitions for predicting fire behavior

Adjective Class	Rate of Spread (chains/hour)
Very Low	0–2
Low	2–5
Moderate	5–20
High	20–50
Very High	50–150
Extreme	>150

Spread rate or rate of spread for this analysis refers to the horizontal distance the flame zone moves per unit of time and is described as chains (66 feet) per hour. Rate of spread, as defined by adjective class by Scott and Burgan (2005), aids fire managers in tactical interpretations.

Fire Type: How a fire spreads, whether through surface fuels on the ground, through the canopy of trees, or a combination of both, is described in this assessment as fire type. Three types of fire spread have modeled in FlamMap and portrayed here: surface, passive crown fire, and active crown fire. There is a high degree in uncertainty when attempting to model fire type and these fire type outputs should not be relied upon for strategic decision making. They are being displayed here as an observation of potential and actual conditions could dictate either increased or decreased potential.

For analysis purposes, we have modeled four different scenarios (Table 3-26) in the analysis area. Scenarios are based upon local RAWS data (years 1970 through 2012) and those used by Scott and Burgan (2005) to represent moderate to extreme fire characteristics. Fire season can occur throughout the year on the Francis Marion however the high to extreme conditions modeled would occur within the peak fire season of February through March.

Figure 3-27 describes the fuel models of the Francis Marion as utilized by fire managers. These fuel models will be entered into BehavePlus in hopes of defining potential fire behavior characteristics and then spatially orientating them across the landscape using ArcGIS.

Surface fire

Passive crown fire

Active crown fire

Figure 3-26. Surface and crown fires

Table 3-26. Weather scenarios

	1-HR Fuel	10-HR Fuel	100-HR Fuel	Live Herb-aceous	Live Woody	20' Wind Speed	Wind Direc-tion
	Fuel Moistures						
Extreme Dry Moisture Scenario 97th Percentile	3.7	6	14	30	60	25	270
Very Dry Moisture Scenario 90th Percentile	4.6	7	15	60	90	20	270
High Scenario 75th Percentile	6.04	8	16	90	120	10	270
Moderate Scenario 50th Percentile	8.44	10	18	120	150	5	270

Table 3-27. Fuel Models of the Francis Marion National Forest

Vegetation Type	Fuel Model	Fire Behavior Notes
Bay Undrained flatwoods; pocosins and pond pine forests	FM4	Fire intensity and fast-spreading fires involve the foliage and live and dead fine woody material in the crowns of a nearly continuous secondary overstory. Besides flammable foliage, dead woody material in the stands significantly contributes to the fire intensity.
Dry Upland pine and mixed pine/hardwood forest	FM2	Fire spread is primarily through the fine herbaceous fuels, either curing or dead. These are surface fires where the herbaceous material, in addition to litter and dead-down stemwood from the open shrub or timber overstory, contributes to the fire intensity. FM2 on the Francis Marion represents a FM7 that has been frequently burned and is considered fire regime condition class I.
	FM7	Fires burn through the surface and shrub strata with equal ease and can occur at higher dead fuel moisture contents because of the flammability of live foliage and other live material. Palmetto-gallberry understory-pine overstory sites are typical and low pocosins may be represented.
Wet Bottomland hardwoods , mixed pine/hardwood forests and cypress-tupelo swamps	FM8	Slow burning ground fires with low flame lengths are generally the case, although the fire may encounter an occasional "jackpot" or heavy fuel concentration that can flare up. Only under severe weather conditions involving high temperatures, low humidities, and high winds do the fuels pose fire hazards.

All scenarios were based upon weather extracted from the RAWS described on page 179 and Figure 3-23 of this section for the years 1970 through 2012.

The *Extreme Dry Moisture Scenario* was based upon 97th percentile weather data. The 97th percentile weather is used to provide an indicator of extreme fire behavior potential because this weather generally only occurs 3 percent of the time.

*Very Dry Moisture Scena*rio was based upon 90th percentile weather data. The 90th percentile conditions generally occur 10 percent of the time.

High Scenario was based upon 75th percentile weather data. The 75th percentile conditions generally occur 25 percent of the time.

Moderate Scenario was based upon 50th percentile weather data. The 50th percentile conditions generally occur 50 percent of the time.

When modeling fire behavior in BehavePlus the greatest driver separating fire behavior outputs in each scenario was wind speed. Wind direction did affect direction of spread and with coastal influence and sea breezes this is a very common concern and occurrence affecting the fire environment of the analysis area. For this analysis however, wind speed adjustments created the greatest difference in both flame length and rate of spread.

BehavePlus Potential Fire Behavior Results: Table 3-28 describes the flame length and rate of spread outputs of the BehavePlus scenario runs. Flame lengths greater than 8 feet along with rates of spread greater than 50 chains per hour have been highlighted in the Table 3-28 to show conditions when heightened situational awareness is required. Any wildland fire exhibiting these characteristics will be difficult to predict and control and hazardous to fire personnel and the impacted public.

A significant finding here is that the analysis area has the elements of weather and fuel required for very active fire behavior; these fires are difficult to suppress and can be very hazardous. It is also observed that any fire with a flame length in excess of 8 feet can be characterized as a problem fire.

Table 3-28. BehavePlus potential fire behavior outputs

	Extreme Dry Scenario – 97th		Very Dry Scenario – 90th		High Scenario – 75th		Moderate Scenario – 50th	
Fuel Model	ROS	FL	ROS	FL	ROS	FL	ROS	FL
FM2	108	11	60	8	15	4	5	3
FM4	209	33	110	24	34	13	12	8
FM7	67	9	40	7	14	4	5	3
FM8	4	2	3	1	1	1	1	1

ArcGIS Potential Fire Behavior Results: In order to spatially model potential fire behavior across the landscape, the aforementioned four weather scenario outputs have been applied to the Forest fuels model layer for spatial analysis. We will not include each spatial version individually here; however, the results from the very dry scenario (flame length and rate of spread) will be used again later in this section. Using ArcGIS to spatially model this potential fire behavior is advantageous because the model should identify areas of concern. BehavePlus has provided a good breakdown of flame length and rate of spread per fuel model within the analysis area. The Forest has a very good understanding of existing fuel models across Forest Service lands; however, the confidence declines on non-Forest lands in the analysis area and were not modeled.

Figure 3-27 shows flame length and rate of spread BehavePlus outputs by fuel model across the Francis Marion. As observed earlier in Table 3-24 and adjective class definitions (Table 3-25) charts, flame lengths of over 8 feet and rate of spread over 50 chains per hour will create fire behavior conditions that are extremely difficult to control and hazardous. Specifically, flame lengths over 8 feet equate to fires that may present serious control problems: torching, crowning, and spotting. For this assessment, both fuel model 2 and 4 exhibit this high to extreme fire

behavior and will be analyzed later in the section in hopes of defining potential problem fire areas.

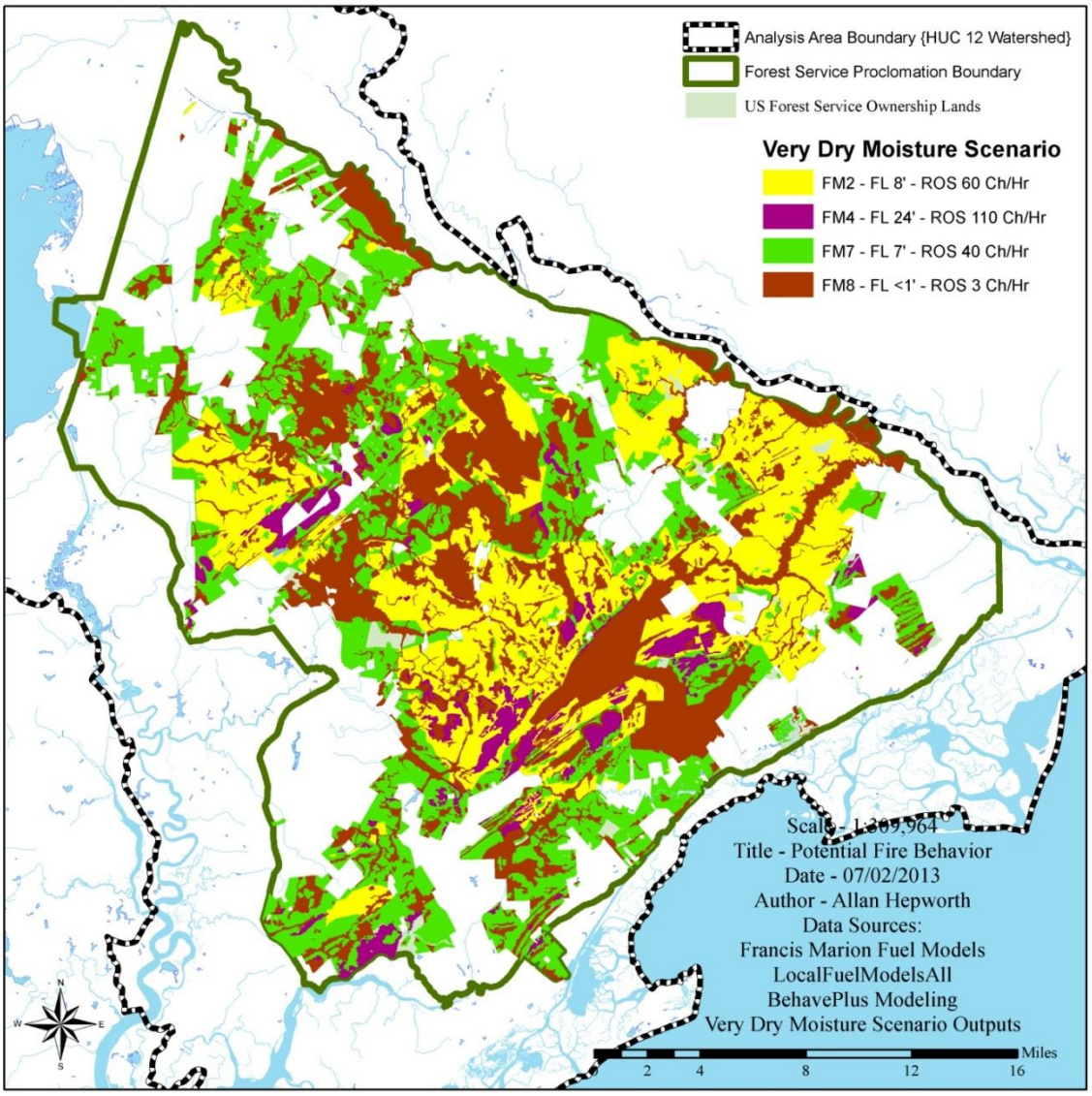


Figure 3-27. Potential fire behavior

Potential Areas of Concern Analysis: To further assess wildland fire occurrence and better understand potential areas of concern, a kernel density analysis was completed (ArcGIS Spatial Analyst extension). By definition the Kernel Density Tool calculates the density of features in a neighborhood around those features. It can be calculated for both point and line features (http://help.arcgis.com/en/arcgisdesktop/10.0/help/index.html#/How_Kernel_Density_works/009z00000011000000/). Results from this analysis will be joined later with the fire behavior outputs described in Figure 3-27 in hopes of refining potential problem fires.

In this analysis, a smoothly curved surface is fitted over each wildfire ignition point. The surface value is highest at the location of the point and diminishes with increasing distance from the point, reaching zero at the search radius distance from the point. The volume under the surface

equals the population field value for the point, or 1 if none is specified. For the fire size density analysis, acres burned per ignition point were used in the population field; for the fire point density analysis, no population value was entered. The density at each output raster cell is calculated by adding the values of all the kernel surfaces where they overlay the raster cell center. All wildland fire occurrences between the years 1992 and 2012 were included in the analysis; kernel density was based on the fire point and the final fire size. Results of each kernel density analysis, as displayed in the Figure 3-28 and Figure 3-29, show the highest densities of acres burned as red while the lowest densities are displayed as green. It is important to note that the search was based on a 1-mile area and that the resulting values have multiple fires and/or large fire acres accounted for in the total. The kernel density analysis was completed in order to spatially identify areas where fires have exceeded initial attack and have grown into extended attack which results in greater exposure and less efficiency. Clustering of smaller size class fires also affect the density and while this may alter the results slightly; it is still a desired component of isolating fire occurrence and potential problem areas.

While Figure 3-28 displayed the density of fire occurrence by final fire size, Figure 3-29 displays all wildland fire occurrence density within 1-mile search.

For additional reference, Figure 3-30 shows the same kernel analysis that was completed for wildland fire occurrence throughout the State of South Carolina. It is observed that fire size densities within the State are highest in the Coastal Plain.

It is important to note that there are numerous variables associated with a wildland fire escape. The above kernel density analyses were completed only to show a general pattern of occurrence in hopes of finding trends. Later in this section, the results of the kernel density analysis will be combined with fire behavior outputs in hopes of spatially defining potential problem fire areas.

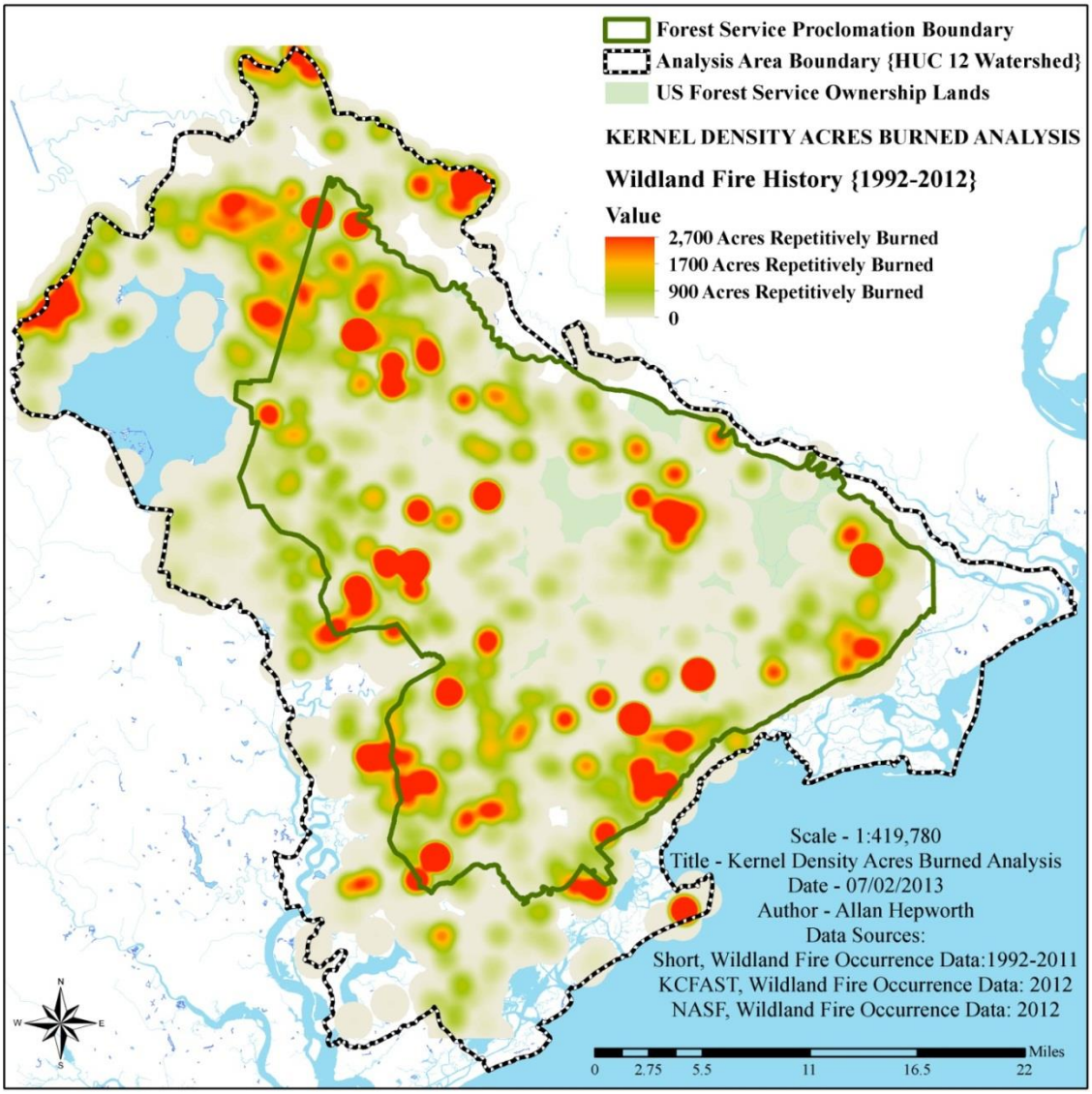


Figure 3-28. Kernel density fire size analysis

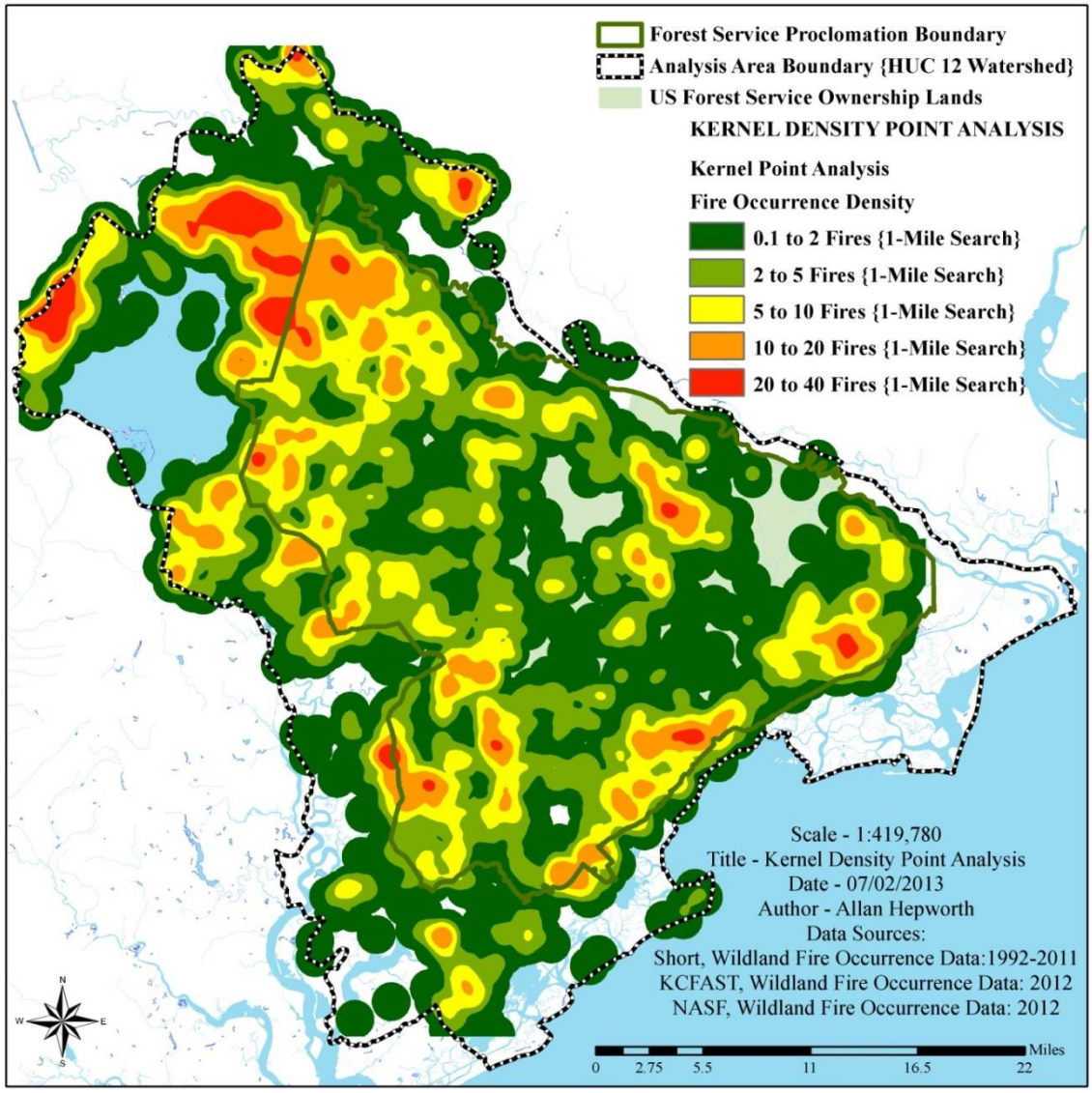


Figure 3-29. Kernel density fire point analysis

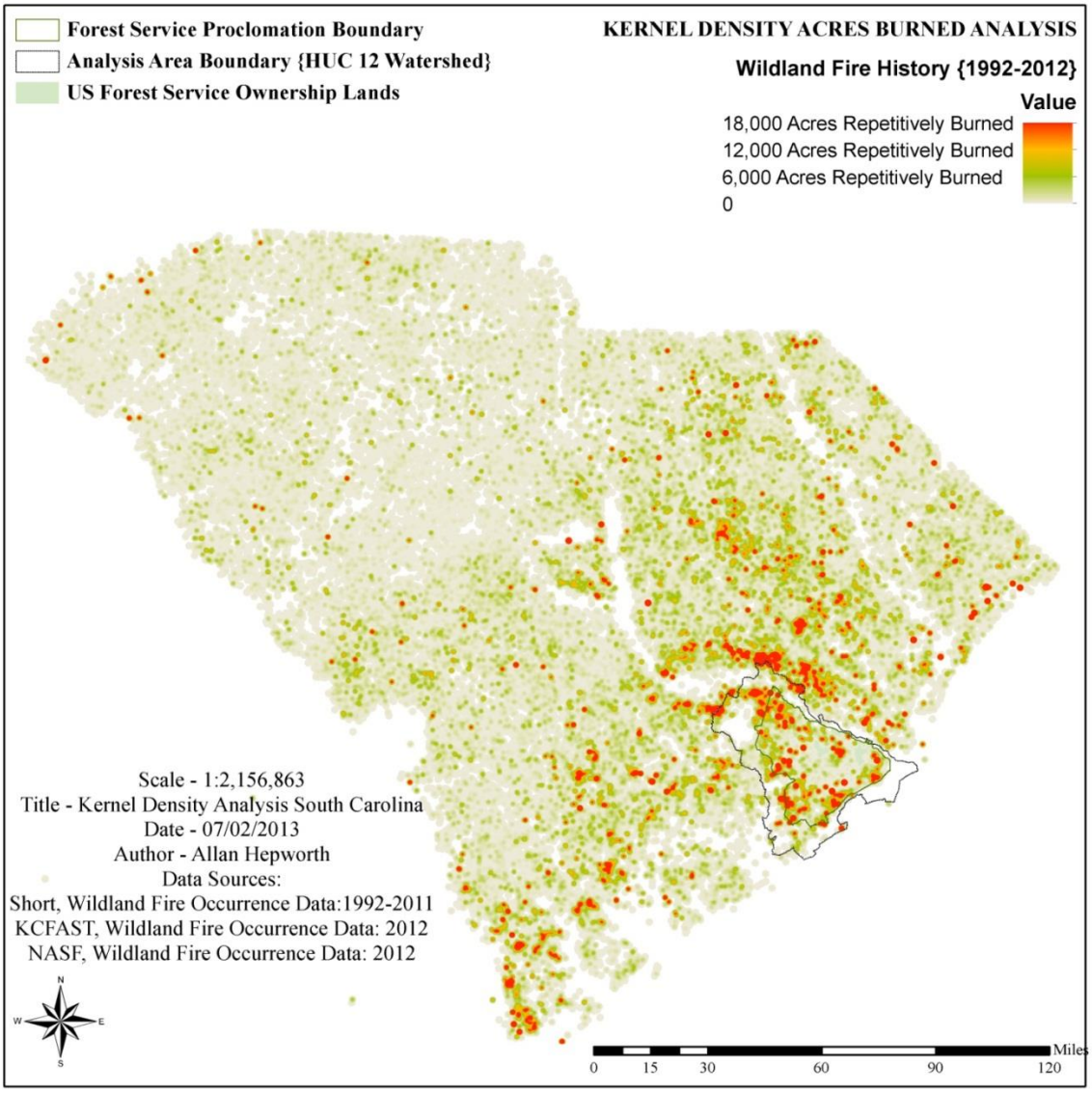


Figure 3-30. Kernel density Coastal Plain fire size analysis

Assessment of Potential Problem Fires: Again, there are multitudes of variables that could be incorporated into this aspect of the analysis; however, we felt that in order to isolate the potential problem fire, an assessment of historical large fire occurrence and the fire behavior indicator that best describes control problem (flame lengths) would be of most benefit. The following assessment will isolate and overlay three main outputs previously discussed; flame length of greater than 8 feet, rate of spread greater than 50 chains/hour, and moderately high to very high wildland fire occurrence density. Once these isolated attributes are overlaid, the areas in which combinations of each occur should represent areas in which problem fires could occur. Again, it is important to remember that this analysis will not be definitive in findings and will only represent potential. The wildland fire environment is extremely variable and occurs across the landscape in many types. A good example can be observed when looking at ecosystem types and their fire regime classifications discussed in section 3.4.1.4 "Current Conditions and Trends." The Atlantic Coastal Plain Upland Longleaf Pine Woodland system has a very short fire regime interval of 1 to 3 years and has historically burned under low to moderate conditions as a surface fire; The Atlantic Coastal Plain Floodplain Systems has a far lengthier fire return interval of over 35 to 200 years typically and burns under more severe conditions as mixed severity. Fire weather, including drought conditions, is a primary driver of fire inclusion and exclusion in the systems throughout the years.

Historical Fire Occurrence and Kernel Density: As noted earlier, historical fire occurrence used a kernel density analysis in ArcGIS to spatially define unplanned ignitions by size and occurrence. Each of these factors is important when looking at patterns or trends. Further extraction of each kernel analysis can be seen in the Figure 3-31. Kernel density attributes of greater than 150 acres burned per square mile and greater than 15 fires per square mile will be used as attributes combined with fire behavior outputs later in attempts of isolating the potential problem fire.

Figure 3-32 shows flame lengths greater than 8 feet and rate of spread greater than 50 chains/hour that were extracted from the BehavePlus Very Dry analysis. Both outputs are key fire behavior indicators that can affect safety, resource utilization, strategy and tactics, and the ability to achieve control objectives.

Figure 3-33 highlights the resulting kernel density outputs and BehavePlus potential fire behavior outputs. Analysis area wildfires (size class E and greater) have been included for reference.

Current Conditions/Potential Wildland Fire Behavior: Figure 3-34 displays the results of the potential problem fire area analysis. The areas notated as "Potential Problem Fire Area" on the map are areas in which each attribute—FL greater than 8 feet, rate of spread greater than 50 chains per hour, over 150 acres burned per square mile, and over 15 fires occurring per square mile—simultaneously occurred. Again, it is important to keep in mind that the numerous fire environment variables combine at any minute of the day throughout the year to create conditions conducive to rapid fire spread or problem fires. This analysis is only intended to highlight potential problem areas based upon past history and future potential.

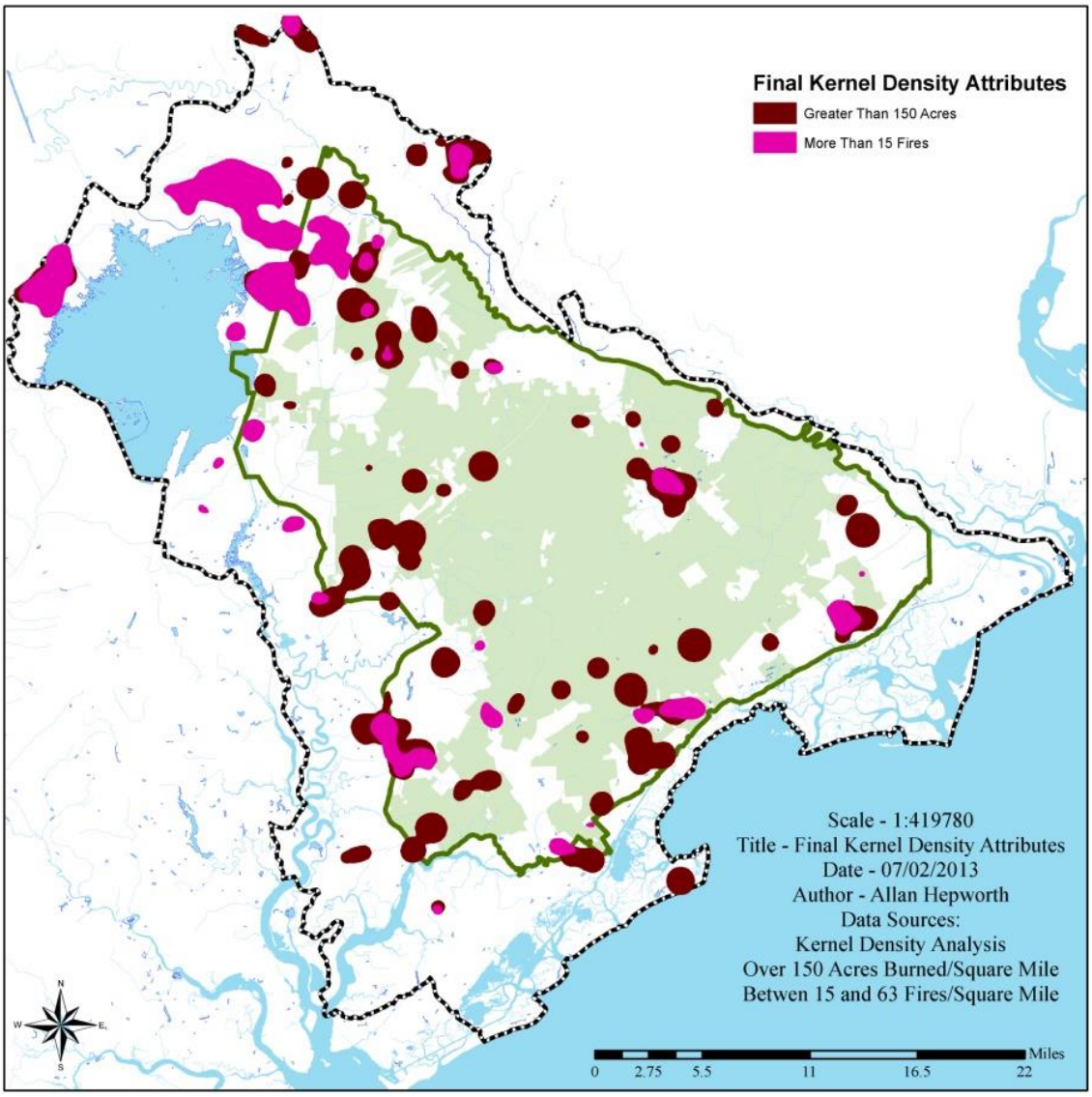


Figure 3-31. Kernal density attributes

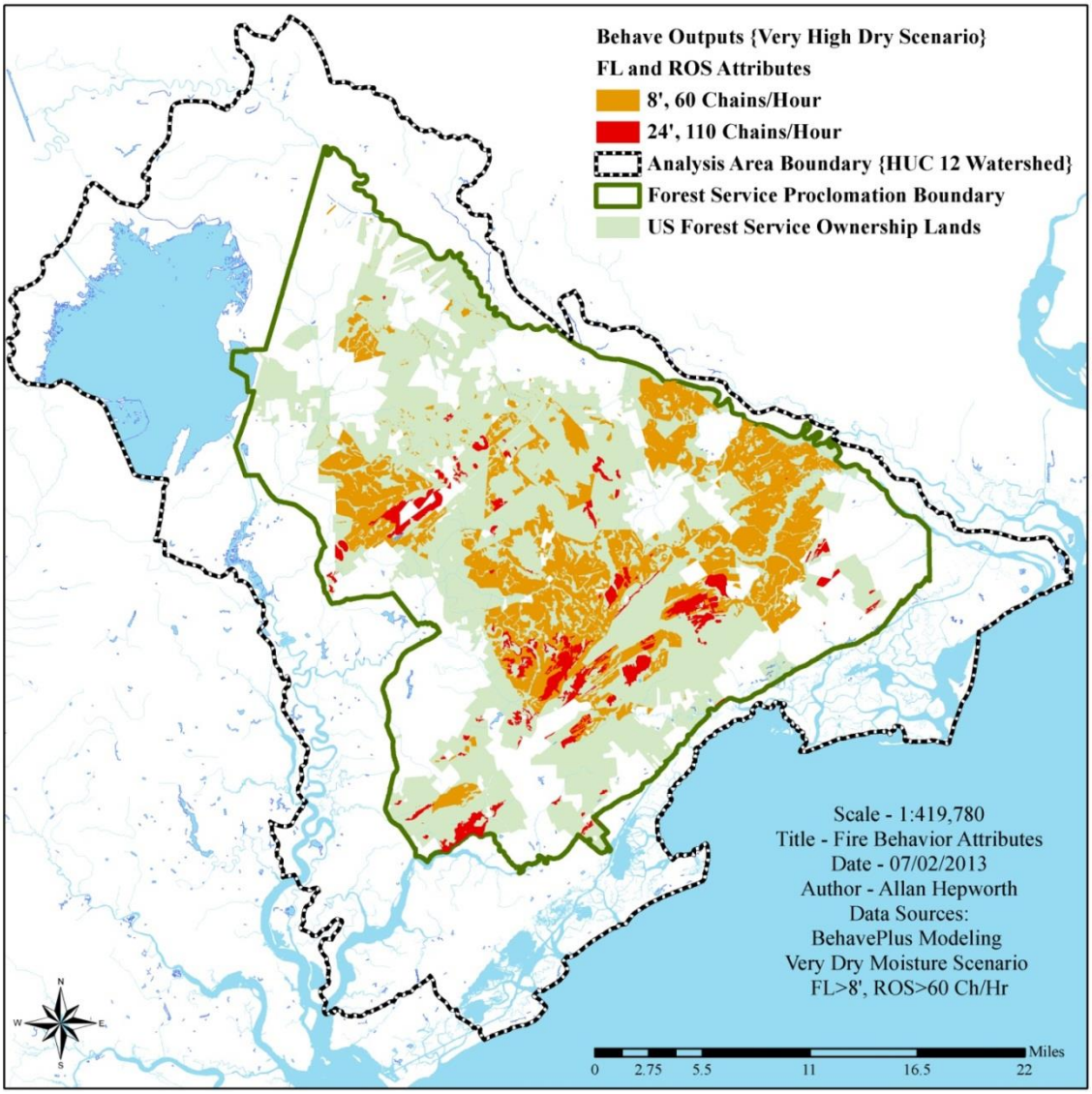


Figure 3-32. Fire behavior attributes

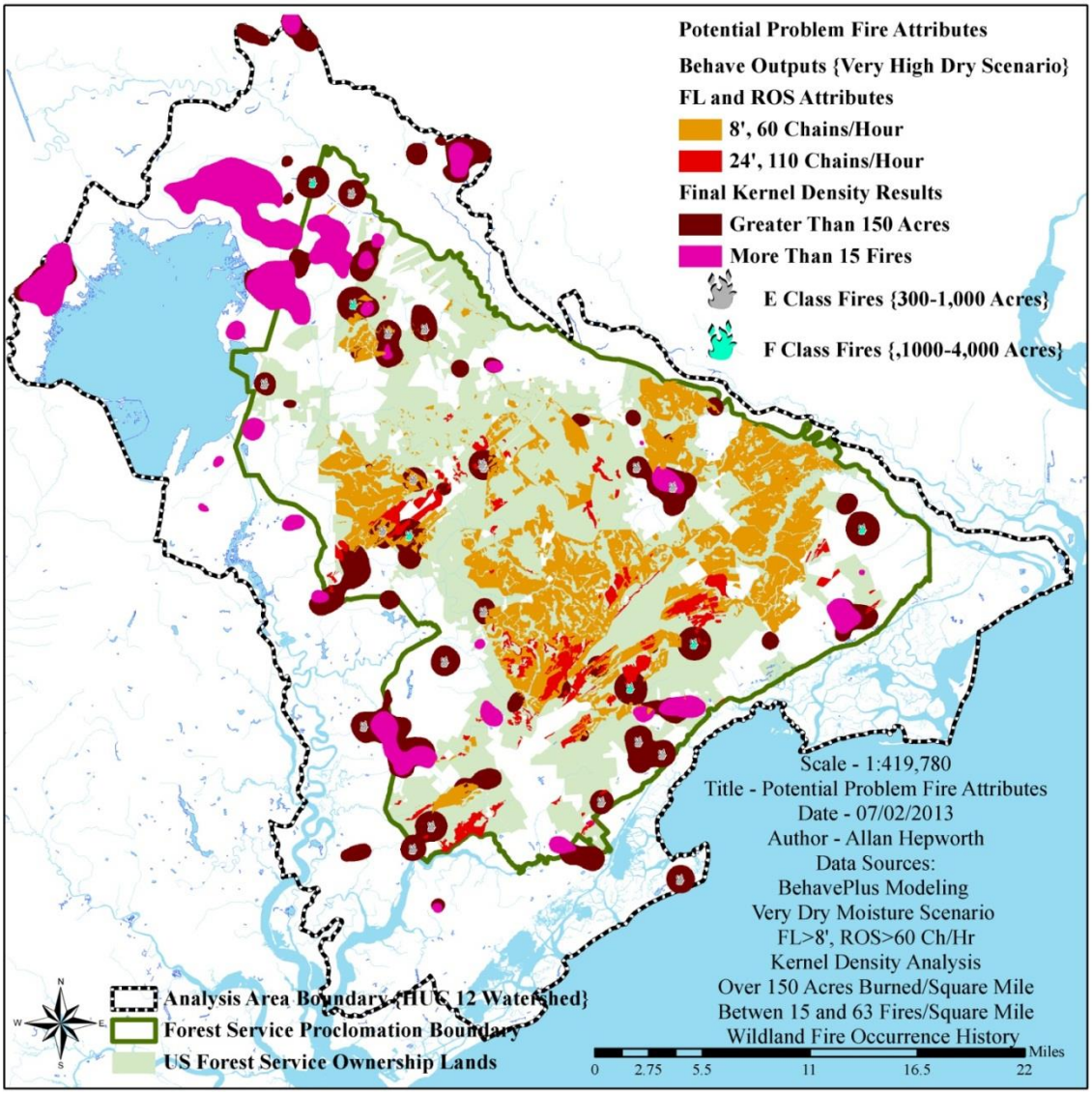


Figure 3-33. Problem fire attributes

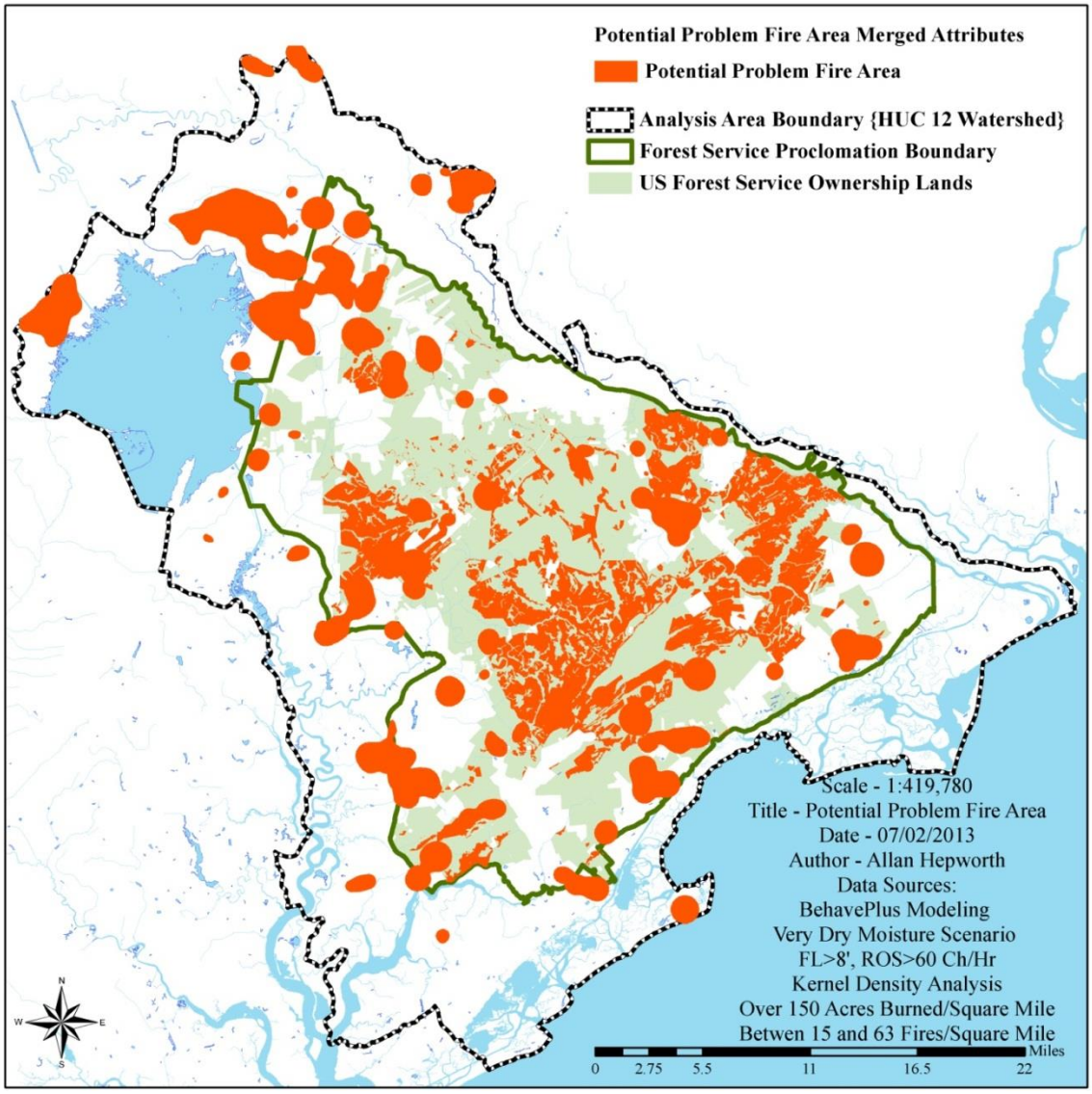


Figure 3-34. Potential problem fire area

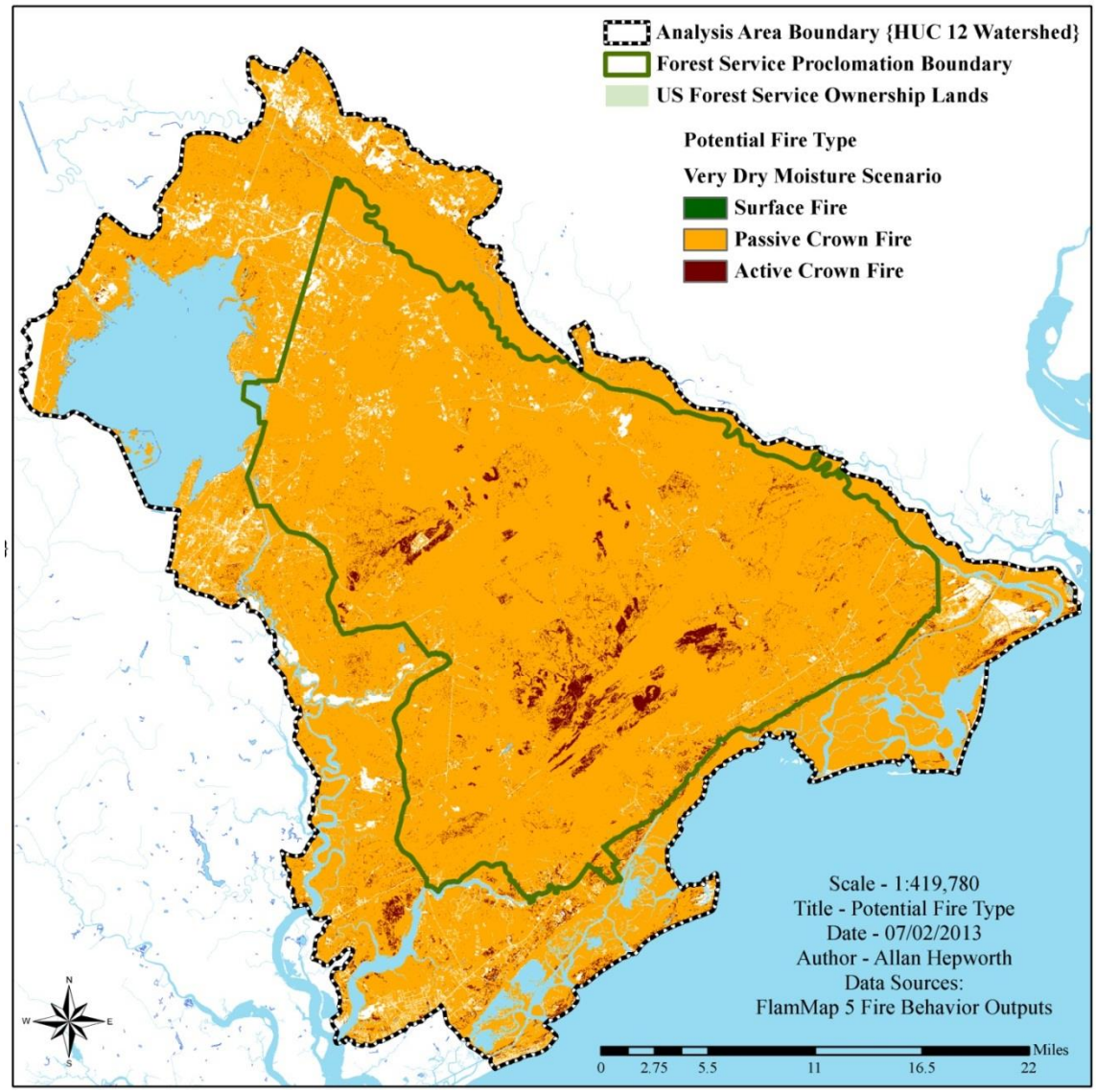


Figure 3-35. Potential fire type

Included for additional reference here is the output of fire type under the very dry scenario (Figure 3-35). As noted previously, FlamMap models three versions of fire type: surface, passive crown, and active crown. Again, as it is extremely difficult to model and predict fire behavior in general, it is even more difficult to model when a surface fire will move from the ground and into the tree crown(s). Inputs to the FlamMap model were: LANDFIRE fuel models, canopy cover, canopy base height, canopy bulk density, elevation, aspect, and slope and Francis Marion fuel models.

Wildland Fire Preparedness: Wildland fire preparedness has been below the most efficient level. The Forest could not fill vacant positions in order to provide 7-day coverage, staff for multi-fire days, and provide an ongoing prevention program.

Shortages of firefighting resources are also common when wildfires and prescribed fire operations occur on the same day. Wildland fire management resources on the Francis Marion share preparedness, fuels, and suppression responsibilities every day of the year. The majority of unplanned ignitions require swift suppression response due to the buildup of wildland-urban interface and the perceived negative impact fire has upon human beings. In order to maximize effectiveness and achieve desired results, fire resources can implement prescribed burns 12 months a year. Fire resources are tasked with implementing a prescribed burn program while simultaneously providing initial attack response, which stresses firefighting capacity and resources. Included within the prescribed fire program are goals and objectives that compete and are all dependent on seasonal conditions and environmental effects.

Federal Budget Allocation: Currently, Federal budgets are drafted and distributed using 5-year averages. The Fire Program Analysis (FPA) is a computer system "designed to provide managers a common, interagency process for strategic fire management planning and budgeting" (http://www.forestsandrangelands.gov/FPA/index.shtml). FPA has been under calibration for the past 5+ years and is not being currently used. Fire managers operate their yearly program of work according to the fiscal year (October 1–September 31). Final budgets are typically approved and implemented in the early summer months (June–July). This leaves managers with the difficult task of planning and operating fire programs for several months without having an actual budget. Figure 3-36 shows Federal budgets allocated to the entire Francis Marion and Sumter National Forests over the past 12 years. Full-time equivalents are those resources funded out of a combination of Hazardous Fuels Reduction (WFHF) and/or Wildland Fire Preparedness (WFPR) funds (an FTE of 1.0 means that the person is equivalent to a full-time worker, while an FTE of 0.5 means the worker is half-time). FTEs here represent all individuals planned in the program of work and are not specific to firefighter qualified individuals. FTE data prior to 2006 is not available. Projected budgets are submitted early in the fiscal year, however budgets are not finalized until mid-way through the fiscal year. Due to the extremely variable nature of wildland fire and fuels, it is very difficult for fire managers to pre-plan, allocate, and spend budgets before the suppression and burning seasons. Fire managers and resources are typically required to allocate and spend money that has not been officially approved.

For perspective relating to overall declining budgets and FTEs, Figure 3-37 highlights the overall decline in FTEs on the Francis Marion and Sumter national forests of 31 percent from fiscal years 1990 to 2012 (http://fsweb.r8.fs.fed.us/ops/fm/HISTORICALBUDGETINFO.htm).

The 2012 South Carolina Property and Firefighter Protection Bill created a recurring source of funding for the replacing of fire equipment for the Forestry Commission. Berkley and Charleston counties each fund five dozers and a wildfire engine that are used in portions of the analysis area. This bill is expected to help generate funds needed to upgrade equipment annually with portions being utilized for firefighter staffing as needed. The funds generated by this bill will lead towards a safer and more efficient workforce with whom managers of the Francis Marion coordinate on a regular basis.

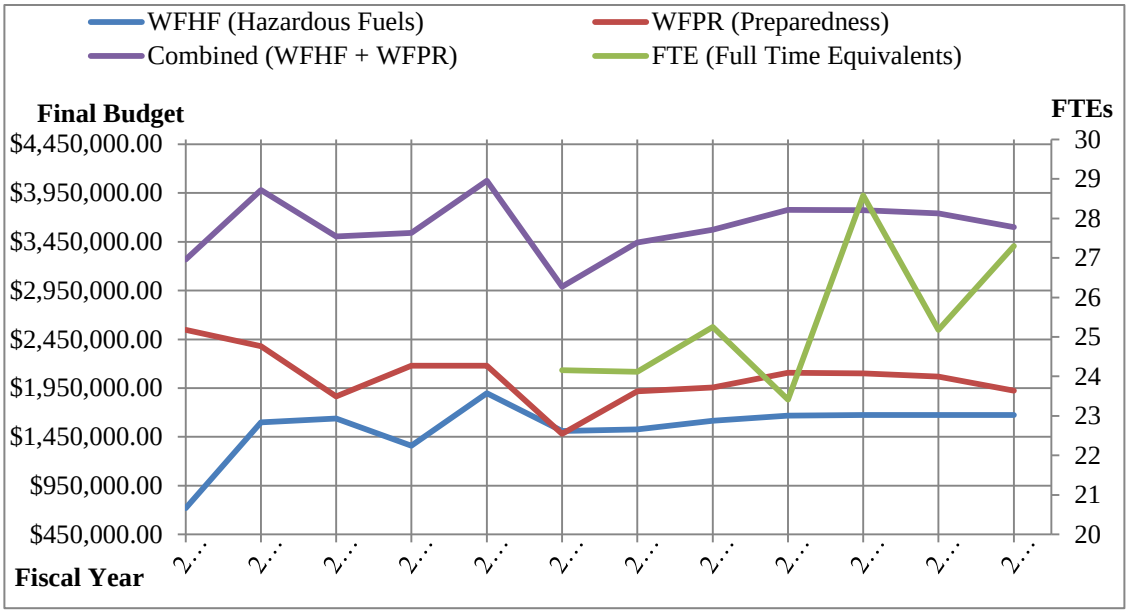


Figure 3-36. Francis Marion and Sumter National Forests budget

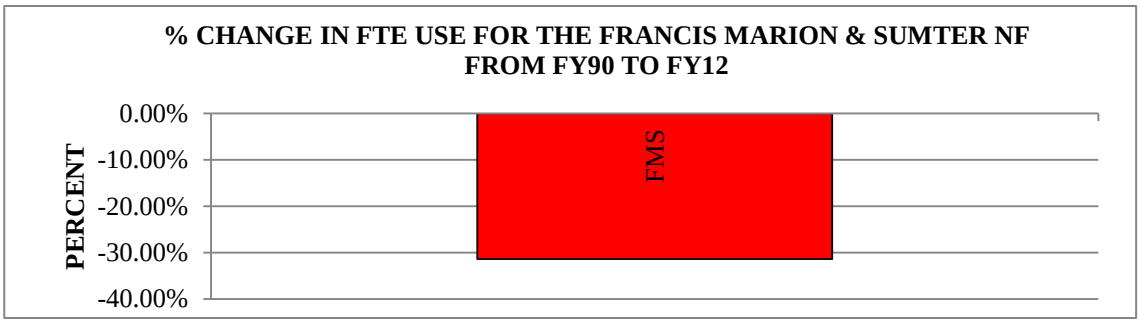


Figure 3-37. FTE decline, fiscal years 2000–2012

Weather and Climate Trends: Fire is a climate influenced ecosystem process recorded in paleoclimate and paleoecology records covering a long span of Earth history (Sommers et al. 2011). Variable weather and climate trends greatly affect the ability to utilize prescribed fire to achieve desired conditions. Key components of weather, such as temperature, relative humidity, wind direction and speed, and air mass stability, all interact over time (daily, monthly, seasonally) to create climate trend conditions either favorable or unfavorable to fire spread and fire effects. The Keetch-Byram Drought Index (KBDI) is a standard wildfire potential risk index that is used in the Southeast for predicting expected fire conditions, fire intensities and control difficulties. As the KBDI increases in value, fire behavior and the complexities of prescribed burning for desired results also increase.

Regional and Forest managers also have standard parameters that detail minimum and maximum weather indices prior to prescribed fire implementation. If these parameters are not met during the days prior to the operation phase then the burn will be canceled or additional variances will be requested.

Figure 3-38 shows the observed daily 1300 hour values which were taken from the predefined analysis area RAWS, which are located in close proximity to the Francis Marion. Each of the indices—BI, ERC, and KBDI—have trended higher during the past 21 years. An interesting observation is that the daily 1000-Hour Fuel Moisture value trend has declined. It should be noted that R^2 values are very low and this can be attributed to the high degree in daily fluctuation in the BI, ERC, and KBDI indices. The 1000-Hour Fuel Moisture is an NFDRS (National Fire Danger Rating System) index that represents the moisture content of dead organic fuels that range in size from 3 to 6 inches. 1000-hour dead fuel moisture levels are computed from a 7-day average boundary condition composed of day length, hours of rain, and daily temperature/humidity ranges. As BI, ERC, and KBDI values are specific to the daily 1300 hour weather observation, 1000-hour moistures are calculated over a 7-day period and do not fluctuate as drastically.

This rise in indices can also be supported and better understood when looking at scientific research relating to climate change. Although there are varying conclusions, the majority of research supports our observation that we have already experienced the impacts of climate change on fire potential and will continue to see worsening conditions. "Fire potential has been increasing across the continental U.S. in recent decades. Larger inter-seasonal and inter-annual variability in fire potential is expected in the future in the Pacific and Atlantic Coasts" (Liu et al. 2012).

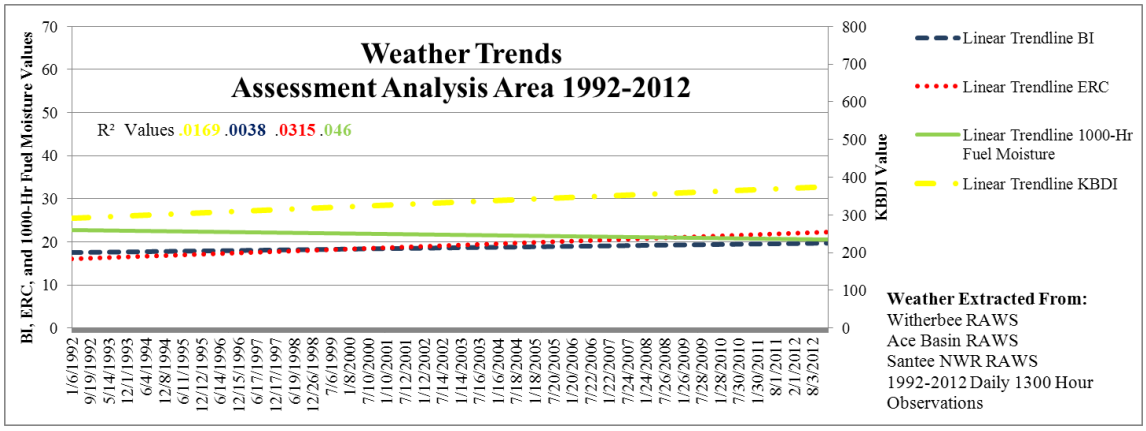


Figure 3-38. Weather indices trends

Other suggested climate change effects:

- It is expected that the fire potential as indicated by KBDI will continue to increase in several regions of the U.S., specifically the Southeast, with future change and increasing temperatures the major contributor (Liu et al. 2012).
- Flannigan et al. (2000) used two GCM (General Circulation Model) simulations of future climate to calculate a seasonal severity rating related to fire intensity and difficulty of fire control. Depending on the GCM used, forest fire seasonal severity rating in the Southeast is projected to increase from 10 to 30 percent by 2060.
- "Ignition probabilities may increase in a warmer world due to increased cloud-to-ground lightning discharges with warming" (Price and Rind 1994).

- "For the south-central and southeastern regions of the United States, their study (Price and Rind [1994], using a general circulation model [GCM]) suggested increases on the order of 40 to 50 percent in the number of wildfires caused by lightning each year. Contributing to these increases is the probable decrease in the average effective precipitation (defined as precipitation minus potential evapotranspiration) over the United States under a changed climate as a result of increased atmospheric carbon dioxide concentrations."
- Another potential effects of climate change on wildland fire and the ability to utilize prescribed fire is that the length of fire season in the Southern U.S., measured by the length of months with high or extreme fire potential level, will increase by 1 to 3 months (Figure 3-39 is taken from Liu et al. [2012] future U.S. wildfire potential trends projected using a dynamically downscaled climate change scenario).

There are a few uncertainties however when looking at climate change forecasts as a measure of future fire potential and the increase in prescribed fire complexities. First, if the climate change forecasts are accurate, the vegetation itself will change (Hansen et al. 2001) as a result, and it is not clear how future vegetation can be used in relation to fuels modeling. Also, as KBDI values represent the relationship between temperatures, rainfall and soil moisture, other important fire prediction inputs such as relative humidity and winds speed were excluded (Liu et al. 2012).

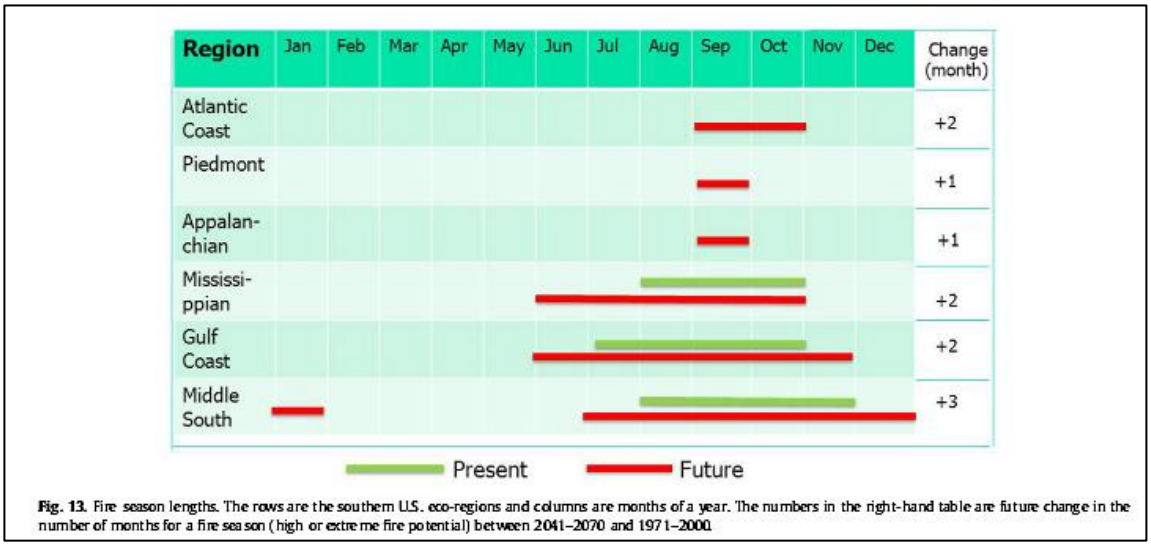


Fig. 13. Fire season lengths. The rows are the southern U.S. eco-regions and columns are months of a year. The numbers in the right-hand table are future change in the number of months for a fire season (high or extreme fire potential) between 2041–2070 and 1971–2000.

Figure 3-39. Wildfire potential season change

3.5 Invasive Species

3.5.1 Invasive Species: Plants

3.5.1.1 Preliminary Findings

►The revised Forest plan and associated FEIS (1996) did not address existing and desired conditions, probable activities related to nonnative invasive plants, or native understory conditions. Several changes in Federal policy related to nonnative invasive species have occurred since 1996. The national forests in the Southern Region began implementing a noxious and invasive weed strategy following the signing of National Executive Order 13112 in June

1999. This order charged Federal agencies to prevent the introduction of invasive species, to detect and respond rapidly to control new invaders, to monitor, to provide for restoration of native species and habitat conditions in invaded ecosystems, to promote public education on invasive species, and to avoid actions likely to cause their introduction and spread.

►Based on Forest Service inventory data, nearly 4,000 records for nonnative invasive plants have been documented on the Forest since 2002. The Federal noxious weed cogongrass (*Imperata cylindrica*) was discovered from three small localized patches in 2007. These patches have essentially been eradicated and none have been discovered since. Japanese climbing fern is found most frequently (over 3,000 records). Over 30,000 acres of inventories, and 1,500 acres of treatments have occurred since 2006, primarily targeting cogongrass, Japanese climbing fern (*Lygodium japonicum*), and the State noxious aquatic/riparian species, common reed (*Phragmites australis*) and Chinese tallow (*Triadica sebifera*).

►Given the lack of adequate regulatory mechanisms, the exponential growth curve of nonnative invasive plant infestations, climate change predictions, and the high costs of control, invasive species will increasingly threaten the composition and function of our terrestrial and aquatic ecological systems on the landscape in the future. The majority of nonnative invasive plants are unregulated on non-Federal lands, and some continue to be sold commercially.

3.5.1.2 Changing Conditions

Nonnative invasive plant species control was not addressed in the table of probable activities, costs, and outputs (revised Forest plan, 1996; Table B-1), nor effects analysis (FEIS 1996).

The national forests in the Southern Region began implementing a noxious and invasive weed strategy following the signing of National Executive Order 13112 in June 1999. This order charged Federal agencies to prevent the introduction of invasive species, to detect and respond rapidly to control new invaders, to monitor, to provide for restoration of native species and habitat conditions in invaded ecosystems, to promote public education on invasive species, and to avoid actions likely to cause their introduction and spread.

The regional forester identified a list of nonnative invasive plant species for the Southern Region in 2001, and nonnative invasive plant species surveys were incorporated into project plant surveys on the Forest beginning in 2002. To date, over 35,000 acres have been surveyed for rare species and nonnative invasive plants (internal Forest data, 2013). Cogongrass surveys have been conducted in conjunction with the State Cogongrass Task Force throughout South Carolina since it was discovered on the Forest in 2007.

Table 3-29 displays nonnative invasive plant species that have been confirmed on the Forest from 2002–2013, and the number of occurrences which have been documented. This does not represent a complete list of invasive plant locations on the Forest, but only what has been documented to date. Japanese climbing fern has become our most aggressive non-invasive plant, originally found sporadically in mesic forests near the Santee River, but now occupying and spreading into Longleaf Pine Ecosystems and right-of-ways throughout the Forest.

Table 3-29. Nonnative invasive plants documented on the Francis Marion National Forest

Latin Name	Common Name	Number of Records Documented
Ailanthus altissima	Tree-of-heaven	1
Albizia julibrissin	Mimosa	41
Alternanthera philoxeroides	Alligatorweed	1
Arthraxon hispidus	Small carpgrass	37
Arundo donax	Giant reed	2
Elaeagnus pungens	Thorny olive	3
Elaeagnus umbellata	Autumn olive	8
Firmiana simplex	Chinese parasol tree	1
Imperata cylindrica	Cogongrass	3
Lemna sp.	Duckweed	1
Lespedeza bicolor	Shrub lespedeza	1[1]
Lespedeza cuneata	Sericea lespedeza	91
Ligustrum lucidum	Glossy privet	2
Ligustrum sinensis	Chinese privet	231
Lolium arundinaceaus	Tall fescue	41[1]
Lonicera japonica	Japanese honeysuckle	138
Ludwigia peploides	Floating primrose-willow	2
Lygodium japonicum	Japanese climbing fern	3,146
Mahonia bealei	Beale's barberry	1
Melia azedarach	Chinaberry	64
Microstegium vimineum	Japanese stiltgrass	90
Paspalum notatum	Bahiagrass	2[1]
Phragmites australis var. *australis*	Phragmites	2
Phyllostachys aurea	Golden bamboo	1
Pueraria montana	Kudzu	2
Pyrus calleryana	Callery pear	1
Pyracantha sp.	Formosa firethorn	1
Rosa multiflora	Multiflora rose	1
Sesbania punica	Rattlebox	1[1]
Triadica sebifera	Chinese tallow	5[1]
Wisteria sinensis	Chinese wisteria	43
Youngia japonica	Asiatic hawk's-beard	1[1]

[1] More locations known but not documented (Mackie, *personal observation*).

3.5.1.3 Scientific Information or Changes in Technology

A wealth of information is available regarding integrated best management practices for invasive plants including prevention, education, control and management, early detection and rapid response (EDDR), and restoration and rehabilitation methods (Miller et al. 2010; www.invasive.org; se-eppc.org; FICMNEW 2003). An invasive plant control project NEPA decision allowing selective treatment of nonnative invasive plant species on up to 3,000 acres was completed in 2001, and over 1,500 acres have been chemically and mechanically treated.

The success of prevention and control activities has been mixed (Wrenn 2012). We continue to increase our knowledge of which species of plants are truly invasive (se-eppc.org). Information regarding the impacts of herbicides and associated surfactants continues to be collected, and new herbicides continue to be developed which have greater selectively, less impact to the environment, and lower costs to the consumer.

3.5.1.4 Broader Landscape

Public and agency awareness of the threat of nonnative invasive species on biodiversity has increased since 1996. The Southeast Exotic Pest Plant Council was established in 1999 to serve as an educational, advisory, and technical support council on all aspect of invasive exotic pest plant issues throughout the Southeast. Forest Service Chief Tom Tidwell named nonnative species as one of the four major threats to the national forest system in 2006. National and regional strategies and management plans were developed in 2004 (USDA Forest Service 2004), 2006 (USDA Forest Service 2006), and the National Invasive Species Management Plan was revised in 2008 (NISC 2008), as was the Forest Service Manual direction regarding nonnative invasive species (FSM 2900–Invasive Species Management, revised in December, 2011to replace FSM 2080–Noxious Weed Management).

The South Carolina Exotic Pest Plant Council has developed State lists of EDDR Species, and also nonnative invasive plant species posing the most threat to natural areas in the State (sc-eppc.org). Across the Southeast, of the 380-plus recognized nonnative plants in southern forests and grasslands, 53 are rated high-to-medium risk for natural communities (Wear and Greis 2012). Invasive plant species of particular concern across the Atlantic Coastal Plain include Chinese tallow, Japanese climbing fern, and cogongrass. Others note Japanese honeysuckle, Chinese privet, bicolor and sericea lespedeza, mimosa, Chinaberry, Japanese stiltgrass, and basket grass (Degarady 2013).

3.5.1.5 Past and Likely Future Trends

Of the terrestrial and riparian nonnative invasive plant species known or likely to occur on the national forest in South Carolina, only cogongrass, common reed, and alligator weed are regulated as state or Federal noxious weed species (http://drpsp.clemson.edu/dpi/npp.htm), or aquatic nuisance species (http://www.dnr.sc.gov/water/envaff/aquatic/index.html). Most nonnative invasive terrestrial plants were introduced for specific functions, such as landscaping, erosion control, or wildlife habitat, with no idea at the time of introduction that they would become invasive. For example, Japanese climbing fern was introduced into Florida as an ornamental plant in the 1930s (Minogue et al. 2009) and now occupies over 50,000 acres of forested land in Florida. It is still being sold in the nursery trade today. Japanese honeysuckle was introduced into the United States in 1906 as ornamental, then later planted by wildlife managers and farmers as forage for deer during late fall and winter. Nonnative invasive plant materials continue to be introduced to the landscape, and not only existing plantings, but any new (unregulated) plant introductions could prove to be invasive in the future. The Southern Forest Futures Project conservatively estimated that the annual spread of nonnative invasive plants in southern forests is 145,000 acres, accelerated by a warming climate and by increasing numbers of forest disturbances that accommodate and support growing human populations (Wear and Greis 2012).

A significant source of uncertainty in projecting pest impacts is the adequacy of prevention and suppression methods: How effective are existing methods compared with those that might be available in the future? How willing and able are land managers or landowners to adopt

management/control methods? And how much funding is available compared to the amount needed for implementation (Wear and Greis 2012)? Prevention methods including the contract provisions requiring the cleaning of timber harvesting equipment prior to moving between infested areas are challenging to implement consistently. Landscape-level cooperation in the form of cooperative weed management areas, are not common, in part due to the fragmented nature of land ownership patterns.

Likely future trends, given the lack of adequate regulatory mechanisms, the exponential growth curve of nonnative invasive plant infestations, and the high costs of treating invasive plants, are an increasing abundance of nonnative invasive plants across the landscape. Nonnative invasive plants will increasingly threaten the composition and function of our terrestrial and aquatic ecological systems on the landscape in the future.

3.5.2 Invasive Species: Aquatic Nuisance Species

The following section is a brief summary of the current conditions and trends. For more information please refer to section 2.1.2 "Aquatic Ecosystems."

3.5.2.1 Preliminary Findings

Please refer to section 2.1.2 "Aquatic Ecosystems" for preliminary findings.

3.5.2.2 Current Condition and Trends

Introductions of nonnative species have had a significant impact on native aquatic fauna in the Coastal Plain Ecoregion. Common carp, flathead catfish, and blue catfish are established in several drainages. Flathead catfish are known to prey on bullheads, darters, shad, suckers, and sunfish. Declines in native species have been observed after the introductions of flathead catfish. Common carp occur in every South Carolina drainage and are considered a pest, but their impact on native fauna is not well known.

The Asian clam has been introduced and has widely spread throughout the U.S., including South Carolina. The effects of the Asian clam on native species are not particularly well understood. Three invasive snail species (*Viviparus georgianus*, *V. purpureus*, and *Bellamya/Cipangopaludina japonica*) are present in Lakes Marion and Lake Moultrie just west of the Forest; however, their impact on native fauna is not known.

The red swamp crayfish has been introduced to South Carolina and has been observed at several locations in the southeastern plains and coastal plain, but it is unclear how widespread it is in the State.

Alligatorweed is found throughout South Carolina. It spreads rapidly by fragmentation. Alligatorweed displaces native vegetation, and disrupts navigation, recreation, and water flow by the formation of impenetrable mats.

The Asian tiger mosquito now occurs Statewide. This species is a competent vector of many viruses including dengue fever, Eastern equine encephalitis, potentially St. Louis and La Crosse encephalitis, as well as dog heartworm.

The USDA Forest Service Southern Region Aquatic Nuisance Species Strategy, Aquatic Animals (Leftwich 2013) provides guidance for managing nuisance species and supports the 2008 South Carolina Aquatic Invasive Species Management Plan. State agencies are recognized as the lead

in controlling the establishment of aquatic nuisance species and managing established aquatic nuisance species both on and off the Forests.

Increased temperatures, changes in rainfall, and other environmental factors affected by climate shifts or change can create ideal conditions for proliferation of invasive plant and animal species, including parasites and pathogens. As climate changes, an increasing number of exotic species likely will migrate to South Carolina. Tilapia currently overwinters in Florida and has become an invasive species and a major management problem. If tilapia were to routinely overwinter in South Carolina it would result in direct competition with native and existing species for space, food, habitat and spawning areas, which could drastically alter natural fish communities. The destruction that nonindigenous peacock bass (*Cichla* spp.) can cause to native fish communities is well documented. In Florida, these fish currently are widespread, but are very temperature dependant and do not typically survive in waters cooler than 60 °F (16 °C). Given current South Carolina winter low temperatures, tilapia is much more of an eminent threat than peacock bass. However, if winter temperatures increase, peacock bass could become a threat in South Carolina.

The primary threats to lentic systems include sedimentation and water chemistry modification. Stresses include roads, drought, forestry management practices, and aquatic nuisance species.

3.5.3 Invasive Species: Terrestrial Animals

3.5.3.1 Preliminary Findings

1. There is no direction in the 1996 Forest plan that responds to invasive species.

2. Preliminary, current, and projected nonnative invasive species (NNIS) data indicate that nonnative invasive species (plants and animals) are somewhat widespread on the Forest. However, the Forest appears to have much smaller densities of NNIS than the Sumter National Forest.

3. The wild pig (*Sus scrofa*) is currently the most widespread and destructive faunal species on the Francis Marion. Free ranging pigs and other livestock occurred on the Forest up until the 1950s and 60s. The Francis Marion has records dating back to the late 1940s and early 1950s indicating the presence of free ranging pigs on the Forest. With such a long history of free ranging pigs, and ongoing popularity of wild pig hunting, it is no surprise that wild pigs still occur throughout most of the Forest. The ability of Forest Service employees to trap and dispatch pigs has been severely limited due to firearms policy for non-law enforcement employees. Since 2009, SCDNR employees have trapped approximately 100 to 125 pigs annually on the Francis Marion. Trapping efforts that were started in 2009 were the first targeted control efforts (other than special pig hunts) that the Forest has implemented in the past 30+ years.

4. Regarding terrestrial animal species, NNIS reptiles and amphibians are the most likely become introduced. Some of the most noteworthy reptile and amphibian species that could be introduced include the burmese python (*Python bivittatus*), African rock python (*Python sebae*), common iguana (*Iguana iguana*), brown anole (*Anolis sagrei*), brown tree snake (*Boiga irregularis*), and Cuban treefrog (*Osteopilus septentrionalis*). Due to its close proximity to a rapidly expanding metropolitan area, it is likely just a matter of time before the aforementioned species make their way to the Francis Marion.

5. The ultimate distribution/range of NNIS reptiles and amphibians throughout the southeastern United States will likely be determined by climate.

6. Another nonnative species of animal that is rapidly expanding across the Southeast and Midwest is the nine-banded armadillo (*Dasypus novemcinctus*). Carriers of leprosy, this species can impact native species. It also feeds on native insects and eggs of wildlife. This species has been confirmed in the nearby town of Moncks Corner (Mark Danaher, *personal observation*, 2012), and is a common occurrence in portions of Dorchester County.

7. There has been considerable controversy and debate surrounding the coyote in the eastern United States. Although it is questionable whether or not the coyote is truly a nonnative invasive species, it is prudent to mention the species in this section simply due to the amount of controversy surrounding the species. According to Kilgo et al. (2012) and Ruth (2010), coyotes were first recorded in South Carolina around 1978, but they were not established Statewide until the mid-1990s. There has been tremendous concern voiced by sportsmen about coyotes, especially deer hunters, after Kilgo et al. (2012) published results from their coyote study on the Savannah River Site. Coyotes may be filling the niche of other large predators that humans have extirpated in the Southeast during the last two centuries (i.e., eastern cougar, Florida panther, and red wolf). Coyotes can be found throughout the Francis Marion National Forest. However, there is very little concern about the presence of this species from and ecological or biological standpoint on the Forest.

3.5.3.2 Current Conditions and Trends

As stated in Executive Order 13112, issued February 3, 1999, a species is considered invasive if it meets these two criteria:

1. It is nonnative to the ecosystem under consideration.

2. Its introduction causes or is likely to cause economic or environmental harm, or harm to human health.

As stated in the USDA Forest Service National Strategy and Implementation Plan for Invasive Species Management (NNIS Implementation Plan): “The Chief of the U.S. Department of Agriculture Forest Service has identified invasive species as one of the four critical threats to our Nation’s ecosystems. We are aware of our significant role in addressing invasive species threats at the local, State, and national levels, as well as internationally. We have found the best opportunity for success comes from working strategically, using all our scientific, management, and partnership resources in unison.”

Nonnative invasive species (NNIS), including both nonnative flora and fauna, can have severe negative ecological and biological effects. Preliminary, current, and projected NNIS data indicate that nonnative invasive species (plants and animals) are somewhat widespread on the Forest. However, the Francis Marion appears to have much smaller densities of NNIS than the Sumter National Forest. Some NNIS have become naturalized on the Francis Marion, and are likely to continue to persist despite any aggressive efforts to treat them on the Forest (e.g., Japanese climbing fern and wild pigs). Nonnative invasive species negatively impact native communities in a number of ways. In some cases, invasive species compete with native species for resources and space. Some invasive species may actually prey directly upon native species. Other NNIS may temporarily or even permanently alter habitats and community structure. Control of invasive species, insects, and diseases is more difficult if untreated properties adjacent to the Forests provide continued opportunities for reinfestation. This is especially true for NNIS plants.

Pig damage to* A. cingulatum *breeding wetland during 2009

Regarding faunal NNIS, the wild pig (*Sus scrofa*) is currently the most widespread and destructive species on the Francis Marion. The pig family (Suidae) is not indigenous to North America, and has the potential to significantly impact ecosystems. The wild pig was introduced to South Carolina through a combination of accidental releases and intentional stockings. Earliest introductions in South Carolina likely date back to the arrival of the first European settlers. Although State laws have been strengthened to prevent translocations of wild pigs, illegal intentional introductions still occur due to the increased popularity of wild pig hunting. Wild pig populations in the Southeast have increased to unprecedented numbers during the 20th

and 21st centuries. This exotic species is likely the most invasive vertebrate species in all of South Carolina, if not the entire Southeast, and is on the USDA Forest Service Southern Region's list of worst invasive species in southern ecosystems. Wild pigs compete with native wildlife species for limited resources, destroy agriculture, prey upon native flora and fauna, damage field crops, and serve as a potential reservoir for diseases and parasites (e.g., pseudorabies, brucellosis and leptospirosis). Coupled with these negative attributes, the pig is a prolific breeder. Sows have an estrous cycle that lasts for 2 days, insuring that a boar in the area will find and breed her. The gestation period is about 115 days and adult sows can produce two litters per year in South Carolina. Typical litter size is 4 to 5, but litters as large as 12 are not uncommon. Piglets are weaned at 3 to 4 months and reach sexual maturity at 5 to 10 months. As such, it is conceivable that both males and females can potentially breed during the same year they are born.

Free ranging pigs and other livestock occurred on the Francis Marion up until the 1950s and 60s. The Francis Marion National Forest has records dating back to the late 1940s and early 1950s indicating the presence of free ranging pigs on the Forest. Most of these animals were live trapped and returned to their owners. The first Francis Marion Management Plan written by A.A. Grumbine in 1936 stated: "Hogs range everywhere over the Forest, causing considerable damage to longleaf pine reproduction. Stock laws in both Berkeley and parts of Charleston County are not enforced and stock are permitted to range at large over the entire Forest." With such a long history of free ranging pigs, and ongoing popularity of wild pig hunting, it is no surprise that wild pigs still occur throughout most of the Francis Marion. During 2009, wild pig damage was documented within known breeding wetlands for the federally threatened frosted flatwoods salamander and Forest sensitive Carolina gopher frog. Since this time, the Francis Marion has concentrated its control efforts within sensitive habitats. However, due to the fact that non-law enforcement Forest Service employees have never been authorized to use firearms, Forest wildlife employees have had to rely on South Carolina Department of Natural Resources employees to dispatch wild pigs. As such, the ability for Forest Service employees to trap and dispatch pigs has been severely limited. Plans are underway which should allow select Forest Service wildlife employees on the Francis Marion and Sumter National Forests to dispatch trapped pigs with firearms. Hopefully, the authorization to use firearms will occur during 2013 or 2014.

During 2011, a total of 118 wild pigs were controlled on the Francis Marion by SCDNR employees. These pigs were primarily trapped in the Waterhorn Hunt Unit, but were also trapped in the Santee and Wambaw hunt units. Since 2009, SCDNR employees have trapped approximately 100 to 125 pigs annually on the Francis Marion. Trapping efforts that were started in 2009 were the first targeted control efforts (other than special pig hunts) that the Francis Marion has implemented in the past 30+ years. Since 2009, six corral-style pig traps have been purchased for the Forest Service by the National Wild Turkey Federation, and additional traps will be purchased during 2013. Plans are currently underway to increase control efforts on the Francis Marion, and increased funding should be available through Stewardship and Knutson Vandenberg sources.

Nonnative species of animals which have the potential to become introduced on the Francis Marion National Forest are numerous. Regarding terrestrial species, NNIS reptiles and amphibians are the most likely become introduced. Some of the most noteworthy reptile and amphibian species that could be introduced include the burmese python (*Python bivittatus*), African rock python (*Python sebae*), common iguana (*Iguana iguana*), brown anole (*Anolis sagrei*), brown tree snake (*Boiga irregularis*), and Cuban treefrog (*Osteopilus septentrionalis*).

The brown anole and Cuban treefrog have already been documented in South Carolina, with the former currently breeding in South Carolina counties such as Jasper and Beaufort. Due to its close proximity to a rapidly expanding metropolitan area, it is likely just a matter of time before the aforementioned species make their way to the Francis Marion. The ultimate distribution/range of NNIS reptiles and amphibians throughout the southeastern United States will likely be determined by climate. Nonetheless, mitigation measures need to be identified for the Francis Marion National Forest should species such as those aforementioned become introduced. By implementing the following elements from the NNIS Implementation Plan, the Francis Marion National Forest will have a process in place to address new NNIS as they are introduced to the Francis Marion National Forest and surrounding area:

1. Prevention: stop invasive species before they arrive.
2. Early detection and rapid response: find new infestations and eliminate them before they become established.
3. Control and management: contain and reduce existing infestations.
4. Rehabilitation and restoration: reclaim native habitats and ecosystems.

Nine-banded Armadillo (*Dasypus novemcinctus*). Another nonnative species of animal that is rapidly expanding across the Southeast and Midwest is the nine-banded armadillo. Nine-banded armadillos are only native to the southwestern United States. This species has been confirmed in the nearby town of Moncks Corner (Mark Danaher, *personal observation*, 2012), and is a common occurrence in Dorchester County, especially between the towns of Summerville and Walterboro. In time the species will undoubtedly inhabit the Francis Marion.

Armadillos can be destructive in natural habitats as they forage for food. They also carry diseases such as St. Louis encephalitis, leptospires, arboviruses, and leprosy. Armadillos primarily feed on beetles, caterpillars, snails, centipedes, and other insects and invertebrates. Plants, eggs, and small verterates likely constitute less than 10 percent of their diet (NatureServe 2013; Figg 1993).

Eastern Coyote (*Canis latrans*). There has been considerable controversy and debate surrounding the coyote in the eastern United States. Although it is questionable whether or not the coyote is truly a nonnative invasive species, it is prudent to mention the species in this section simply due to the amount of controversy surrounding the species. Throughout its native range, the coyote garnered a considerable amount of attention among Native Americans. The coyote has also been known as Medicine Dog, Brother, Old Man Coyote and Little Wolf. According to Zuni legend, the coyote taught man to hunt. The Sioux believe that the coyote taught humans about useful plants. Tribes of the Pacific Northwest tell how the coyote put salmon in the rivers and taught men how to make fish traps and salmon spears. The Sen people say the coyote taught them to take the sweet juice out of cactus.

The original distribution of the coyote included the plains and mountains of western and central North America from eastern Alaska to Indiana and southward to Costa Rica (Young and Jackson 1951; Paradiso 1968; Kays et al. 2009; Toomey et al. 2012). In the last four decades, the coyote has expanded eastward across the United States due to the elimination of the wolves and other large carnivores from their former ranges (Leopold and Chamberlain 2001; Griep et al. 2007). Although the dramatic range expansion of coyotes during the last 90 years is partly explained by changes to the landscape and local extinctions of wolves, but hybridization may also have facilitated their movement (Kays et al. 2009). Because the Eastern Coyote tends to be larger

bodied and possess more wolf-like attributes than its western relative (e.g., larger pack size), the eastern coyote has potential to more closely fill the niche of the extirpated gray and red wolf, perhaps feeding more heavily on overabundant suburban mammals such as the white-tailed deer (Parker 2005; Ballard et al. 1999; Toomey et al. 2012). The popularity of using coyotes in fox pens and for hunting/running with hounds has created demand for the illegal translocation of coyotes throughout the Southeast, and has no doubt played a role in the spread of coyotes. According to Kilgo et al. (2012) and Ruth (2010), coyotes were first recorded in South Carolina around 1978, but they were not established statewide until the mid-1990s. There has been tremendous concern voiced by sportsmen about coyotes, especially deer hunters, after Kilgo et al. (2012) published results from their coyote study on the Savannah River Site. It is likely the coyote is filling the niche of other large predators that humans have extirpated in the Southeast during the last two centuries (i.e., eastern cougar, Florida panther, and red wolf). Species such as the white-tailed deer and wild turkey have thrived throughout the western United States for thousands of years (the native range of the coyote). As such, there is no reason why the white-tailed deer and other species cannot similarly cope with the introduction and spread of coyotes throughout the eastern United States. Coyotes can be found throughout the Francis Marion. However, there is very little concern about the presence of this species from and ecological or biological standpoint on the Forest.

Melanistic coyote on the Francis Marion National Forest

3.6 Natural Vegetation Succession

3.6.1.1 Preliminary Findings

1. Stresses to natural succession on the Francis Marion National Forest include lack of frequent prescribed fire, an over-abundance of loblolly pine due to past land management practices, and past wetland modifications.

3.6.1.2 Changing Conditions

Natural succession refers to changes in the development of vegetation in an area over time, particularly following natural disturbances such as wildfire, wind and hurricanes, insect and disease outbreaks, or droughts. The FEIS, "Vegetation" section of the 1996 revised Forest plan notes that in the absence of ecological community classification and a potential natural vegetation classification system, dominant forest cover types and age-class distributions for each type represent successional stages reflecting different plant communities (page III-24). To integrate new information regarding natural ecosystems and associated vegetation dynamics, this discussion on natural succession is consistent with vegetation dynamics from biophysical settings models in LANDFIRE (www.landfire.gov) as they relate to our ecological systems framework, as well as information on land use history. Stresses to natural succession on the Francis Marion National Forest include lack of frequent prescribed fire, an over-abundance of loblolly pine due to past land management practices, and past wetland modifications.

3.6.1.3 Past and Likely Future Trends

People have harvested timber from southern forests for more than 300 years since European settlement, and most forests have been harvested multiple times (Wear and Greis 2012). By 1900 it was evident that longleaf pine replaced itself only sporadically in a tiny percentage of its former landscape, and by 1967, loblolly pine plantations had been established on 12,460,000 acres throughout the Southeast (Frost 1993). The near elimination of once-dominant longleaf pine ecosystems was perhaps the greatest ecosystem alteration resulting from intensive forest management and land use conversion in the South (Wear and Greis 2012). Loblolly pine is currently the most abundant tree species on the Francis Marion occupying over 87,317 acres. Much of our loblolly pine was planted and then increased significantly following Hurricane Hugo (USDA Forest Service 1985). Although a component of bottomland forests originally, loblolly pine is a versatile tree species and a prolific seeder, and will continue to aggressively alter natural succession on all ecological system types in the future.

The acreage in loblolly pine forest types on the Forest has declined from 114,917 acres in 1985 (FEIS 1985). This decline represents a shift to changes from pure loblolly pine to mixtures with hardwoods, though the majority of our loblolly pine forests occur on wet pine savanna and longleaf pine woodland sites (Simon and Hayden 2013; Longleaf Assessment 2010). Loblolly pine regeneration has also affected the composition of dry to mesic oak hickory forests, mesic hardwoods, bottomland and stream floodplain forests, nonriverine swamp hardwood forests, and maritime forests. Trends in forest cover are consistent with declines in the acreage prescribed burned on the Forest over time and acreage in potential longleaf ecological systems prescribed burned (see section 3.4 "Wildland Fire and Fuels"). In the absence of prescribed fire, many of our loblolly pine stands have hardwood tree subcanopy/midstory and hardwood shrubs/sprouts, though distinguishing between fire-suppressed longleaf and original presettlement hardwood or hardwood pine can be problematic once the characteristic longleaf groundcover has become lost (Glitzenstein and Streng 2011). Loblolly pine forests on mesic and wetter sites will often have an abundance of early successional woody species, such as red maple and sweetgum, and little understory development. Many of our loblolly pine stands have been managed with high basal areas and on wet pine savanna sites, loblolly pine regeneration will interfere with understory development.

When prescribed burned frequently and thinned, loblolly pine forests can behave similarly to longleaf pine woodlands and savannas, and support a diversity of wildlife and plant species.

Longleaf pine ecosystems are "fire-climax" ecosystems; that is, the climax or old-growth vegetation is dependent on frequent prescribed fire. In the complete absence of fire longleaf pine forests succeed to Southern mixed hardwood forests (Ware et al. 1993) or mixed hardwoods with loblolly pine (2013 FS VEG data and trends; Glitzenstein and Streng 2011).

With frequent prescribed fire including a growing-season component, there tends to be an abundant and diverse ground cover of grasses and herbaceous plants (Natureserve 2012; Glitzenstein and Streng 2003). Long-term fire suppression depresses species diversity in these systems, resulting in a substantial hardwood understory and mid-story dominance (Brockway 2002). Mesic, wet-mesic, and more fertile sites succeed the most rapidly to woody shrubs, loblolly pine, and hardwoods in the absence of fire, and comprise the most fire-dependent vegetation, whereas dry and xeric sites may persist with more minimal management (Glitzenstein and Streng 2003; Brockway 2002; Frost 1993).

Acres of inland swamps were cleared for fields and when the inland rice system was abandoned towards the end of the Revolutionary War the fields reverted to swamp forests. Porcher and Rayner (2001) provide an extensive account of effects of the rice culture on the natural history of the Lowcountry, including the inland swamp system period and the tidal system period. In coastal wetlands, the swamp forests that developed on abandoned rice fields have become climax communities (Porcher and Rayner 2001). Abandoned rice fields follow a "hydrach" succession (succession that begins in water), shifting from floating species, to emergent species, and ultimately raising the soil level by trapping sediment, decomposition, and a reduction of soil moisture through transpiration. Once the soil is raised above the water table, the wind-borne fruits of bald cypress, red maple, willow, loblolly pine, cottonwood, sweet gum, and swamp gum can be established. On the Francis Marion, we have much evidence of draining and diking, though many areas have succeeded to forested swamps and maritime forests. Within the salt marsh, maritime forest comprised of palmetto, live oak, and coastal red cedar have established themselves along old dikes created when the marshes were once drained. In the absence of intensive or frequent disturbance, nonriverine swamps will continue to be abundant on the Forest (SE-GAP 2013), though oaks may establish less readily in these forests following intensive disturbance.

3.7 Natural Disturbance

3.7.1 Preliminary Findings

1. There is no direction in the 1996 Forest plan that responds to natural disturbances.

2. The time period 2000–2009 was noted as an exceptionally dry period on the Francis Marion National Forest. The average annual precipitation according to PRISM (Gibson et al. 2002) for 2000–2009 was 47.4 inches, while the longer-term average from 1980–2009 discussed previously in this section was 50.6 inches.

3. In the Southeast region, the area of moderate to severe spring and summer drought has increased by 12 percent and 14 percent, respectively, since the mid-1970s. Even in the fall months when precipitation tended to increase in most of the region, the extent of drought increased by 9 percent (Karl et al. 2009).

4. Analysis of the NASH (North Atlantic Subtropical High) system since the 1940s, as well as analysis of future projections, suggest the system will likely intensify, expand, and more farther westward in the 21st century with the increase of carbon dioxide. This shift

indicates the increased likelihoods of both extreme rainfall events and drought over the southeastern United States in the future (Li et al. 2010).

5. The average intensity of tropical cyclones is expected to increase by 2 to 11 percent while the frequency of tropical cyclones occurrence is expected to decrease by 6 to 34 percent. The most intense storms produce by far the greatest damage (Biasutti et al. 2011). A recent study using an operational hurricane prediction model shows a tendency towards increased frequency of Atlantic category 4 and 5 hurricanes over the 21st century (Knuston et al. 2010).

6. Storm-surge incidence from tropical cyclones would be expected to increase (Knuston et al. 2010).

7. In a study of the Hobcaw Forest in coastal South Carolina after Hurricane Hugo, Gresham reported that longleaf pine (*Pinus palustris*) suffered less damage than loblolly pine (*Pinus taeda*) (Johnsen et al. 2009).

8. The number of freezing days in the Southeast has declined by 4 to 7 days per year for most of the region since the mid-1970s (Karl et al. 2009).

9. For the SRES [Special Report on Emissions Scenarios] A2 and A1B emission scenarios, a 1-in-20-year hottest day is likely to become a 1-in-2-year annual extreme by the end of the 21st century (Senevirante et al. 2012).

10. Recent studies have shown that sea level may rise by 0.8 to 2.0 meters (31 to 78 inches) by 2100 (Pfeffer et al. 2008). Even with no increase in hurricane intensity, coastal inundation and shoreline retreat would increase as sea-level rise accelerates, which is one of the most certain and most costly consequences of a warming climate (Karl et al. 2009).

11. Adjacent to the Forest, Cape Romain's barrier islands will suffer from the effects of coastal erosion in addition to inundation as sea levels rise. The low sea-level-rise scenario predicts a 31 centimeter rise in sea level and 22 centimeters of subsidence by the year 2100. As a result, sea-level rise may inundate 51.4 percent of Cape Romain. Thus, the barrier islands may become fragmented as a result of subsidence and sea-level rise. The destruction of these barrier islands will allow increased wave energies onto the refuge's marsh (Daniels et al. 1993).

12. In reviewing the results from the Sea Level Rise Affecting Marshes Model (SLAMM) predicted landcover change between 2000 and 2050 is dominated by conversion of upland undeveloped to scrub/shrub transitional marsh. The latter half of the century (2050 to 2100) is characterized by more gradual conversion of scrub/shrub transitional marsh to other conditions, including salt marsh.

13. For information regarding gap phase regeneration and tree fall gaps refer to the LANDFIRE disturbance descriptions in section 2.1.1.6 "Past and Likely Future Trends".

14. For information regarding historic burning and lightning fires refer to Section 3.4 of this report.

3.7.1.1 Existing Information

The best available science information provided in this section is based primarily on models and literature derived through the use of the Template for Assessing Climate Change Impacts and Management Options (TACCIMO) http://www.taccimo.sgcp.ncsu.edu/

3.7.1.2 Current Condition and Trends

Broad scale disturbance regimes including flooding, drought, tornadoes, downbursts, ice storms, hurricanes, temperature extremes and sea-level rise have impacted the Francis Marion National Forest in the past and are anticipated in the future.

Flooding and Drought

The time period 2000 to 2009 was noted as an exceptionally dry period on the Francis Marion. The average annual precipitation according to PRISM (Gibson et al. 2002) for 2000 to 2009 was 47.4 inches, while the longer-term average from 1980 to 2009 discussed previously in this section was 50.6 inches. This 9.4 percent decrease in precipitation, apparent when comparing the notably dry period to the longer-term average, illustrates the potential practical implications that shifts in long-term climate can have. In addition, the inter-annual variability responsible for the decrease in precipitation largely played out in two exceptionally dry years in 2001 and 2007 (Figure 3-40).

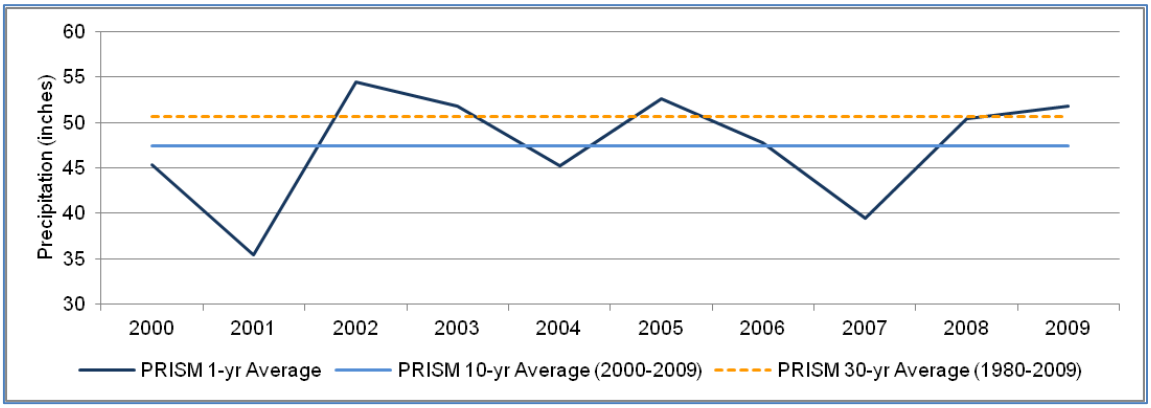


Figure 3-40. Time series graph of annual total precipitation from 2000–2009 with longer-term annual averages from 2000–2009 and 1980–2009

ForWarn is a web-based tool that provides systematic long-term vegetation monitoring using moderate resolution satellite-based imagery (Hargrove et al. 2009). ForWarn uses the Normalized Difference Vegetation Index (NDVI) which provides a robust measure of greenness across seasons. Summed to the year, NDVI provides a measure of vegetative productivity which is often linked to stand age, health, or vigor which can vary with disturbance or climate stress. When the annual average NDVI is plotted with annual precipitation, illustrating the decline in NDVI associated with dry years and the rate of recovery following the return to average or above precipitation (Figure 3-41). While climate explains much of the variability in NDVI, other factors, including management activities, can play a role.

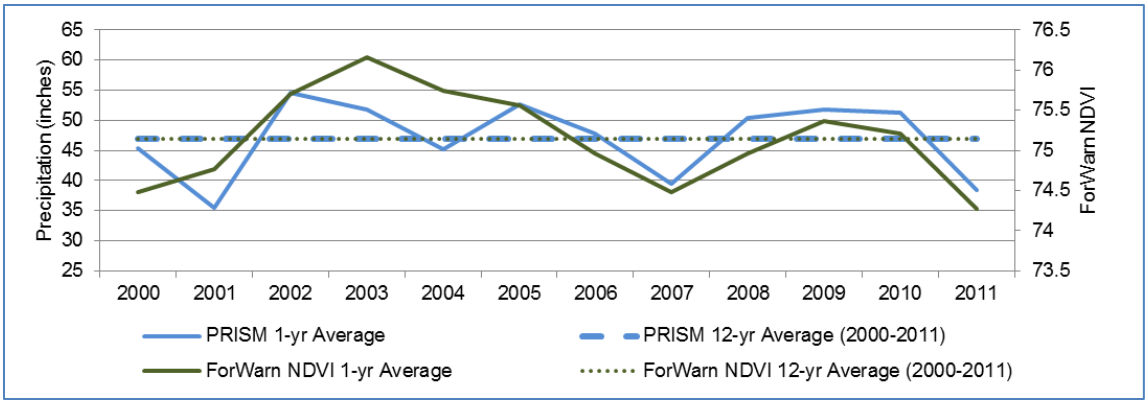


Figure 3-41. Time series graph of annual total precipitation and NDVI from 2000–2011 with longer-term annual averages from 2000–2011

In reviewing the literature, the following findings can be made concerning the current conditions and trends of flooding and drought in the southeastern states:

- Extreme precipitation events and intensity of precipitation will increase (Fay et al. 2008; Biasutti et al. 2011; Pitchford et al. 2011).
- The area of moderate to severe spring and summer drought has increased by 12 percent and 14 percent, respectively, since the mid-1970s. Even in the fall months when precipitation tended to increase in most of the region, the extent of drought increased by 9 percent (Karl et al. 2009).
- The NASH (North Atlantic Subtropical High) system will likely intensify, expand, and more farther westward in the 21st century with the increase of carbon dioxide, indicating increased likelihoods of both extreme rainfall events and drought over the southeastern United States in the future (Li et al. 2010).
- Temperature increases will intensify the hydrological cycle, and extremes (floods and droughts) are likely to increase in frequency and magnitude (Wu et al. 2012).

Tornadoes and Downbursts

North American cyclone numbers have increased over the last 50 years, with no statistically significant change in cyclone intensity (Seneviratne et al. 2012). However, there is a much uncertainty in the current and predicted trends of tornadoes and downbursts (as per the literature as follows):

- Current understanding of tornado and downburst formation from supercell storms is very incomplete and climate-change model predictions sufficiently coarse, that predictions of changes in frequency, size, intensity, or timing of these extreme events must be regarded as highly uncertain (Peterson 2000).
- Until knowledge of supercell thunderstorm formation is much improved, we can have only limited confidence in long-term projections about tornado and downburst climatology, although some very general suggestions warn that an increase in number and severity would be consistent with predicted continental and regional-scale changes in climate (Peterson 2000).
- An increase in atmospheric greenhouse gas concentrations may cause some of the atmospheric conditions conductive to tornadoes such as atmospheric instability to

increase due to increasing temperature and humidity, while others such as vertical shear to decrease due to reduced pole-to-equator temperature gradient. But the literature on these phenomena is extremely limited with low confidence projections of changes in such small-scale systems (Seneviratne et al. 2012).

Ice Storms

In reviewing the literature there is limited knowledge concerning the current and projected trends of ice storms. A few findings are as follows:

- Ice storms increase potential fire risk by elevating fuel loads and limiting stand access (Bragg et al. 2003; Irland et al. 2000).
- Ice storms are the primary cause of tree mortality with substantial ice damage historically occurring at least once a decade along a belt from Texas to New England (Galik and Jackson 2009).
- Forests may suffer less damage during each ice storm event of similar severity in a future with higher atmospheric carbon dioxide (McCarthy et al. 2006).
- In a changing climate, the Mid-Atlantic is likely to experience less snow and ice (Galick and Jackson 2009).

Hurricanes

With Hurricane Hugo in 1989, the Francis Marion was significantly impacted. In reviewing the literature, the current and predicted trends are as follows:

- Future warming may lead to an upward trend in tropical cyclone destructive potential, and taking into account an increasing coastal population, a substantial increase in hurricane-related losses in the 21st century (Emanuel 2005).
- Numbers of strong tropical cyclones in the North Atlantic have been above normal (based on 1981 to 2000) in 9 of the last 11 years, culminating in the record breaking 2005 season. Globally, estimates of the potential destructiveness of hurricanes show a substantial upward trend since the mid-1970s, with a trend toward longer lifetimes and greater storm intensity (Nicholls and Alexander 2007).
- The intensity of Atlantic hurricanes is likely to increase during this century with higher peak wind speeds, rainfall intensity, and storm surge height and strength (Karl et al. 2009).
- The average intensity of tropical cyclones is expected to increase by 2 to 11 percent while the frequency of tropical cyclones occurrence is expected to decrease by 6 to 34 percent. The most intense storms produce by far the greatest damage (Biasutti et al. 2011).
- A recent study using an operational hurricane prediction model shows a tendency towards increased frequency of Atlantic category 4 and 5 hurricanes over the 21st century (Knuston et al. 2010).
- Tropical-cyclone-related rainfall rates are likely to increase with greenhouse warming (Knuston et al. 2010).
- Storm-surge incidence from tropical cyclones would be expected to increase (Knuston et al. 2010).

- In a study of the Hobcaw Forest in coastal South Carolina, after Hurricane Hugo, Gresham reported that longleaf pine (*Pinus palustris*) suffered less damage than loblolly pine (*Pinus taeda*) (Johnsen et al. 2009).
- The two ends of the species susceptibility to hurricane damage are loblolly pine and baldcypress (*Taxodium distichum*). When both of these southern Florida types were exposed to Hurricane Andrew in 1992, the pines experienced 25 to 40 percent damage while the bald cypress was less than 10 percent) (McNulty 2002).

Temperature Extremes

In reviewing the literature, there are numerous citations that state minimum temperatures have significantly increased over the last 50 years with a few citations expecting heat waves to become more intense in the future (a few findings are listed here).

- Since 1950 it is very likely that there had been a reduction in the frequency of extreme low temperatures, with a smaller increase in the frequency of extreme high temperatures (Nicholls and Alexander 2007).
- The number of freezing days in the Southeast has declined by 4 to 7 days per year for most of the region since the mid-1970s (Karl et al. 2009).
- Regarding projections of extreme temperatures, the AR4 [IPCC Assessment Report 4] noted that cold episodes were projected to decrease significantly in a future warmer climate and considered it very likely that heat waves would be more intense, more frequent, and last longer in a future warmer climate (Senevirante et al. 2012).
- For the SRES [Special Report on Emissions Scenarios] A2 and A1B emission scenarios a 1-in-20-year hottest day is likely to become a 1-in-2-year annual extreme by the end of the 21st century (Senevirante et al. 2012).
- In the Gulf, a typical winter in the last decades of this century will be as warm as the warmest winter ever recorded and the coolest summers will be as hot or hotter than any summer in the last century, in 95 percent of the years, summer temperatures will be unprecedented (Biasutti et al. 2011).

Sea-level Rise

In reviewing the literature it is clear that sea-level rise is currently occurring and is projected to increase through this century (Figure 3-43).

The current and predicted trends are as follows:

- The average rate of sea-level rise over the 20th century was 1.7 millimeters (0.067 inches) year from analysis of tide-gauge data. The rate has increased in recent years. From 1993 to 2003, the average rate of sea-level rise was approximately 3.1 millimeters (0.12 inches) year with approximately half that rate coming from thermal expansion. Sea level is presently rising at a rate of 3.4 to 3.5 millimeters (0.13 to 0.14 inches) per year based on satellite-based sea surface altimetry, tide gauges, and global gravity measurements (Biasutti et al. 2011).
- The mean sea level trend is 3.15 millimeters per year with a 95 percent confidence interval of ± 0.25 millimeters per year based on monthly mean sea level data from 1921 to 2006 which is equivalent to a change of 1.03 feet in 100 years (Figure 3-42) (NOAA 2013).

- Recent studies have shown that sea level may rise by 0.8 to 2.0 meters (31 to 78 inches) by 2100 (Pfeffer et al. 2008).
- Estimates of future global sea-level rise have recently been revised upwards. Estimates by Rahmstorf (2007) suggest global sea-level rise could increase by 4 feet (48 inches) by 2100, depending on the warming scenario employed, as opposed to a very modest 0.6 to 1.9 feet (7 to 23 inches) projected in the most recent assessment of the IPCC (Intergovernmental Panel on Climate Change) (Moser et al. 2009).
- Groundwater inundation may be an impact of sea-level rise by the latter half of the century to those areas lying between 0.66 and 1 meter (26 and 39 inches) of the mean higher high water (MHHW) (Rotzoll and Fletcher 2012).
- It is considered likely that sea-level rise has led to a change in extreme coastal high water levels (Seneviratne et al. 2012).
- It is generally understood that sea-level rise is expected to result in the inland migration of the mixing zone between fresh and saline water (Werner and Simmons 2009).
- Even with no increase in hurricane intensity, coastal inundation and shoreline retreat would increase as sea-level rise accelerates, which is one of the most certain and most costly consequences of a warming climate (Karl et al. 2009).
- Cape Romain's barrier islands will suffer from the effects of coastal erosion in addition to inundation as sea levels rise. Thus, the barrier islands may become fragmented as a result of subsidence and sea-level rise. The destruction of these barrier islands will allow increased wave energies to enter and attack the refuge's marsh (Daniels et al. 1993).
- The low sea-level rise scenario predicts a 31 centimeter rise in sea level and 22 centimeters of subsidence by the year 2100. This 53 centimeters is very close to, or exceeds, the estimated vertical accretion rate of the marsh (i.e., ~5 millimeters/year), and as a result, may inundate 51.4 percent of Cape Romain (Daniels et al. 1993).
- The higher sea level will reduce the relative height of the barrier islands, making them more vulnerable to overwash by tropical storms (Chavez-Ramirez & Wehtje 2011).
- From an ecological perspective, one of the major implications of rising seas in potential inundation of vast areas of low-lying emergent Spartina dominated marshes, which are among the most productive ecosystems on earth (Erwin et al. 2006).

Sea-level Rise Affecting Marshes Model (SLAMM). The SLAMM model summarizes landcover changes driven by sea-level rise. It was parameterized and run by the Biodiversity and Spatial Information Center (BaSIC) at North Carolina State University. SLAMM simulates geomorphological processes (i.e., accretion, erosion, and marsh migration). It was run on the Francis Marion based on analysis of results corresponding to the A2 (high emissions) sea-level rise scenario from the Intergovernmental Panel on Climate Change (IPCC 2001) (Figure 3-42).

In reviewing the results predicted landcover change between 2000 and 2050 is dominated by conversion of upland undeveloped to scrub/shrub transitional marsh. The latter half of the century (2050 to 2100) is characterized by more gradual conversion of scrub/shrub transitional marsh to other conditions, including salt marsh.

The geographic distribution of land cover classes, including a map highlighting areas predicted to experience varying degrees of change is included in Figure 3-43.

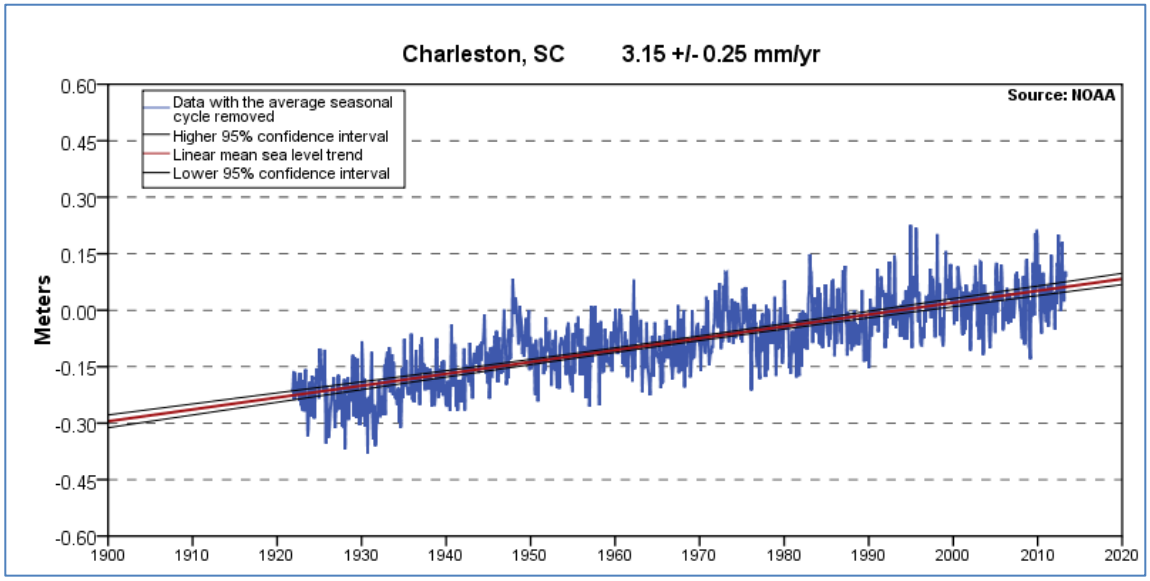


Figure 3-42. Sea-level rise from 1900 to 2012 at Charleston, South Carolina (NOAA 2013)

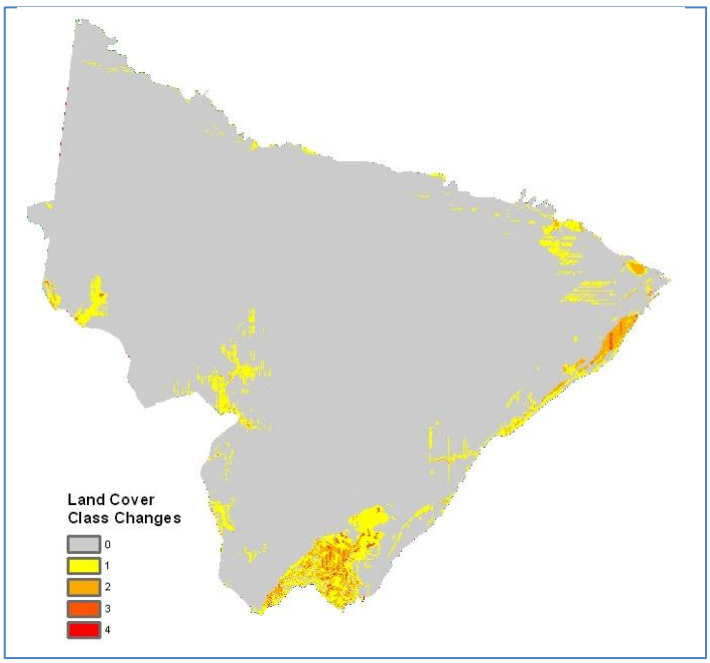


Figure 3-43. Sea-level rise; change in landcover class by 2100

3.8 Human Disturbance

3.8.1.1 Preliminary Findings

1. Projects now in planning stages are expected to complete most of first thinning harvest needed in stands that were established after Hurricane Hugo. It is anticipated in the future more regeneration harvests will occur.

2. The Francis Marion National Forest has an active prescribed burning program, with an average of 35,000 acres burned annually. Prescribed fire accomplishments since 2007 have varied from year to year with the highest acreage of 40,263 being achieved in fiscal year 2008 and the lowest acres occurring in 2012. During fiscal years 2007–2012 over 200,000 total acres of ecosystem were treated with prescribed fire.

3. Approximately 576 miles of national forest system Roads exist on the Francis Marion National Forest.

4. One of the greatest trends currently affecting the management of land ownership status and land use and access patterns is the escalating housing development on private rural lands adjacent to existing national forest. Farms, including those adjacent to Forest, are being lost to development (Forest Service 2007). Development on adjacent properties has led to an increased number of issues with trespass, illegal trails, title claims, encroachments, and law enforcement problems such as poaching, illegal posting of Forest lands, and user conflicts.

5. Hydrologic modifications (dams, dikes, ditches, bedding, etc.) are specifically designed to alter hydrology.

3.8.1.2 Introduction

Human ground-disturbing activities act as system drivers and stressors on the Francis Marion National Forest. Major disturbances including timber harvest, prescribed burning, roads, land use and hydrologic modifications will be discussed in this section.

3.8.1.3 Current Conditions and Trends

Timber Harvest

From 1996 through 2012, the Francis Marion sold commercial thinning harvests on approximately 30,000 acres of land. Commercial thinning has been the sole focus of timber harvest on the Forest since a few years after Hurricane Hugo. This emphasis is beginning to shift. Projects now in planning stages are expected to complete most of first-thinning harvest needed in stands that were established after Hurricane Hugo. It is anticipated in the future more regeneration harvests will occur.

For additional information on this topic please refer to section 8.4 "Timber."

Prescribed Burning

The Francis Marion National Forest has an active prescribed burning program, with an average of 35,000 acres burned annually. Prescribed fire accomplishments since 2007 have varied from year to year with the highest acreage of 40,263 being achieved in fiscal year 2008 and the lowest acres occurring in 2012. During fiscal years 2007–2012 over 200,000 total acres of ecosystem were treated with prescribed fire.

The percent of the longleaf pine forest types which have been prescribed burned in the last 5 years has increased from fiscal year 2008 (60 percent) to fiscal year 2012 (66 percent).

The desired condition for the Forest is to maintain fire-adapted ecosystems using a fire-return interval of once every 3 years (Forest Plan 1996). The total area that would benefit from fire is approximately 160,000 acres. The current levels of treating 30,000 to 40,000 acres per year falls short of the 53,000 acres needed. Fire is critical to restoring and maintaining red-cockaded woodpecker habitat and fire-dependent communities. The Francis Marion is using different strategies to increase the number of acres burned annually.

Please refer to section 3.4 "Wildland Fire/Fuels", section 4 "Carbon Assessment", and section 2.2 "Air Quality" for more information on the effects of prescribed burning.

Roads

There are approximately 576 miles of national forest system roads on the Francis Marion National Forest. Efforts to maintain these roads are in accord with established road management objectives and are described by maintenance levels 1–5. Maintenance level 1 is custodial maintenance and corresponds to roadways not generally maintained for vehicle travel; maintenance level 2 is maintained for passage by high clearance vehicles; maintenance levels 3–5 are maintained for passenger vehicles at increasing levels of comfort and speed. Maintenance level 5 roads are typically paved.

Please refer to section 11.4 "Roads" for more information.

Land Uses

The Francis Marion National Forest is comprised of approximately 259,537 acres (based on 2012 GIS, basic surface area layer).

The Forest is experiencing the effects of urbanization at a higher level than other forests in the Southern Region. Acquisition funds have been very limited while timber companies have been divesting themselves of large acreages near the Forest. Land acquisition has become increasingly difficult and private landowners are less willing to allow public access across their lands (2008 Forest Plan Review).

One of the greatest trends currently affecting the management of land ownership status and land use and access patterns is the escalating housing development on private rural lands adjacent to existing national forest. These also include farms adjacent to Forest system lands (Forest Service 2007). Development on adjacent properties has led to an increased number of issues with trespass, illegal trails, title claims, encroachments and law enforcement problems such as poaching, illegal posting of Forest lands, and user conflicts.

Please refer to section 14.1.2 "Land Status and Ownership" and 14.1.3 "Land Use" for more information.

Hydrologic Modifications

Hydrologic modifications (dams, dikes, ditches, bedding, etc.) are specifically designed to alter hydrology, either by (1) draining wetlands and wet areas to make the areas accessible; (2) draining riparian areas for some of the same purposes; (3) retaining water for rice or indigo culture; (4) retaining water for other uses such as hydroelectric generation, recreation, irrigation, flow transfer, etc.; (5) channelizing or straightening streams to reduce flooding, and (6) bedding, draining, or modifying sites to convert bottomland hardwoods to pine. *Please refer to section "1.3 Watersheds" for more information.*

3.8.1.4 Information Needs

Information needs include the distribution and trends of nonnative invasive plants and the adequacy of prevention and control methods.

4 Carbon Assessment

4.1.1.1 Preliminary Findings

1. Carbon dioxide concentration in late 2011 was at 391 parts per million, a level that is higher than at any point during the past 800,000 years (Global Carbon Project 2011).

2. Human activities have led directly to increases in GHG (greenhouse gases) concentrations which have enhanced the greenhouse effect. Predicted GHG emission scenarios, based on different assumptions about population growth and energy use, etc., are used by climate scientists to predict future trends of GHG atmospheric concentrations that are the climate-driving forces used for climate change projections (Daniels et al. 2012).

3. Worldwide, forests offset up to 60 percent of global carbon dioxide emissions from fossil fuel combustion (Pan et al. 2011).

4. Management practices, such as thinning, revegetation, and prescribed fire, designed to maintain or restore forests may, at least over the short- or midterm, reduce total carbon stocks. However, not taking action to improve ecological health will likely result in substantially lower carbon stocks and substantially increased carbon emissions in the future as the result of forest decline, severe wildfire, and losses from storms, insects, and disease (FS Strategic Framework for Responding to Climate Change).

5. A century of forest conservation and restoration has turned America's forests from a net carbon source into a net carbon sink (National Roadmap for Responding to Climate Change). America's forests, including the carbon stored in wood products and landfills, offset about 12 to 16 percent of the carbon dioxide that Americans emitted (US EPA 2012).

6. The 2011 estimates for the Francis Marion National Forest total 18.5 teragrams (Tg or million metric tonnes) ± 2.8 Tg of carbon. This represents about 0.04 percent of the total of approximately 45,278 Tg of carbon in forests of the coterminous United States (EPA 2012). The average density of forest carbon is about 71.5 metric tonnes per acre.

7. Annual harvests from the Francis Marion National Forest average 33132.8 ccf (Forest Service Cut and Sold Reports 2008–2012). On average 0.12 percent of the standing total stocks of carbon are harvested each year. Of this annual harvest an estimated more than 30 percent will remain in a sequestered state (wood products in use or in landfills) after 50 years.

8. Annual prescribed burning emits carbon at the rate of about 8.4 percent of the carbon in down wood and litter, but only 0.8 percent of the total standing carbon stocks.

9. The most recent inventories indicate that the Francis Marion National Forest is a carbon sink, with most recent 5-year accumulations at the rate of about 14 percent. Although this increase is within the sampling error for the inventory, the trends reflect that a continued increase at this rate is likely.

4.1.1.2 Introduction

The Forest Service, in its Strategic Framework for Responding to Climate Change, has reported that "climate change is one of the greatest challenges to sustainable management of forests and grasslands and to human well-being that we have ever faced, because rates of change will likely exceed many ecosystems' capabilities to naturally adapt" (USDA Forest Service 2008).

Excess greenhouse gases (GHGs) in the atmosphere are a measureable and significant contributor to a changing climate. Their concentrations have steadily increased over the past century (IPCC 2007). Carbon in the atmosphere (carbon dioxide) has the largest effect of GHGs on the climate. Growth rates of atmospheric carbon dioxide are relatively high, with 2010 experiencing one of the largest annual growth rates of the past decade (Global Carbon Project 2011). Carbon dioxide concentration in late 2011 was at 391 parts per million, a level that is higher than at any point during the past 800,000 years (Global Carbon Project 2011) (Figure 4-1) (see also the Climate Primer [http://www.fs.fed.us/ccrc/climate-basics/climate-primer.shtml]).

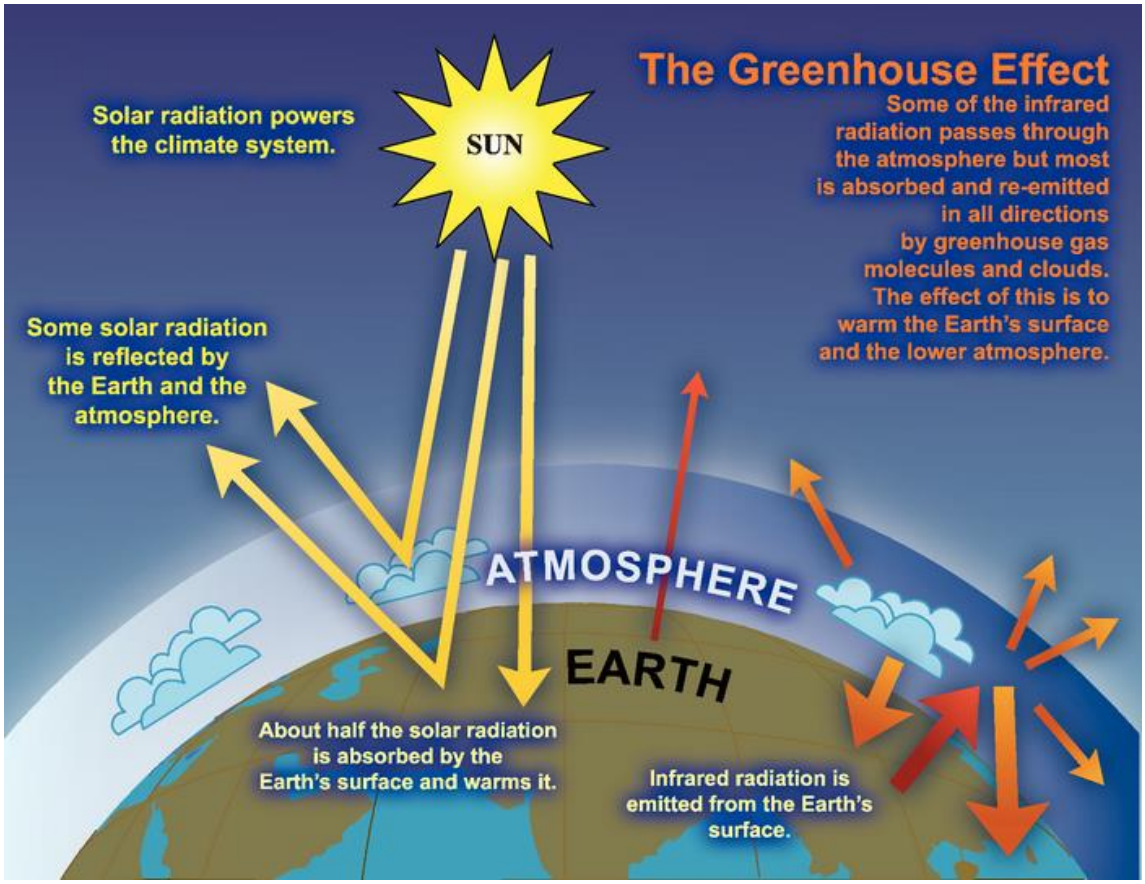


Figure 4-1. A simplified model of the greenhouse effect

Source: IPCC 2007a; chapter 1.

Human activities have led directly to increases in GHG concentrations, which has enhanced the greenhouse effect. Predicted GHG emission scenarios, based on different assumptions about population growth and energy use, etc., are used by climate scientists to predict future trends of GHG atmospheric concentrations that are the climate-driving forces used for climate change projections (Daniels et al. 2012).

Carbon sequestration is the process by which atmospheric carbon dioxide is taken up by trees, grasses, and other plants through photosynthesis and stored as carbon in biomass (trunks, branches, foliage, and roots) and soils. Forests help to mitigate the climate effects of increasing atmospheric carbon dioxide concentrations by removing carbon from the atmosphere through the process of vegetative growth and storing carbon as biomass. Worldwide, forests offset up to 60 percent of global carbon dioxide emissions from fossil fuel combustion (Pan et al. 2011). However, loss of forest land cover is responsible for about 20 percent of global human caused carbon emissions (IPCC 2007). In the U.S., forests and carbon stored in wood products are a net carbon sink and offset about 13 percent of total U.S GHG emissions (EPA 2011). Forest management activities will play a critical role in ensuring that forests remain a net carbon sink."

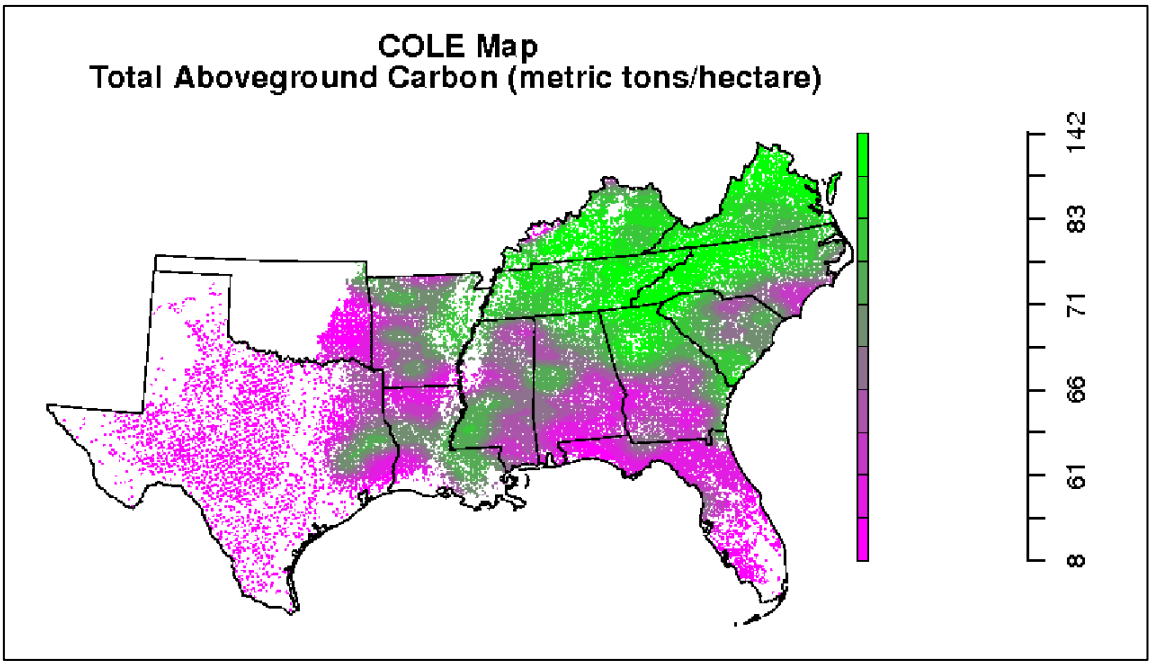


Figure 4-2. Forest carbon distribution in the Southeaster U.S.

Source: Carbon On-Line Estimator, Van Deusen and Heath

Climate Change Mitigation

The Intergovernmental Panel on Climate Change (IPCC) defines mitigation as an "intervention to reduce the emissions or enhance the storage of greenhouse gases" (http://www.ipcc.ch/).

Forests and other ecosystems as carbon sinks provide for mitigation by their very existence as they absorb carbon dioxide, removing it from the atmosphere. Forest management activities will play a critical role in ensuring that forests remain net carbon sinks (National Roadmap for Responding to Climate Change).

The following is from the Forest Service Strategic Framework for Responding to Climate Change:

> The Nation's forests and grasslands provide clean water, scenic beauty, biodiversity, outdoor recreation, natural resource-based jobs, forest products, renewable energy and carbon sequestration. Sustainable forestry practices can increase the ability of forests to sequester atmospheric carbon and help to mitigate the effects of changing climate while enhancing other

beneficial services (http://www.fs.fed.us/ecosystemservices/carbon.shtml). Effective climate change mitigation requires balancing carbon sequestration with other beneficial services.

Mitigation is predicated on adaptation: the long-term capacity of ecosystems to capture and store carbon depends in large part on their ability to adapt to a rapidly changing climate. Adaptation and mitigation strategies must complement each other. Carbon accrues in trees, soil, and wood products and the use of wood-based substitutes for fossil fuel-based products decreases the amount of greenhouse gas emissions. However, slow growth and the loss of vegetation to storms, insects, disease, and wildfire results in reduced or direct loss of carbon to the atmosphere. Forest management is important for protecting, maintaining and improving the amount of carbon stored in forests.

Harvested biomass converted into solid wood products, biofuels, or other fossil fuel substitutes may add to the stocks of sequestered carbon which help to mitigate climate change.

Most opportunities for increased sequestration of greenhouse gases on forests and grasslands are on private lands.

Management practices, such as thinning, revegetation and prescribed fire, designed to maintain or restore forests may, at least over the short- or mid-term, reduce total carbon stocks. However, not taking action to improve ecological health will likely result in substantially lower carbon stocks and substantially increased carbon emissions in the future as the result of forest decline, severe wildfire, and losses from storms, insects, and disease.

The Forest Service was established to help stem the Nation's dramatic forest losses in the 19th century. Within a single generation, net forest loss almost entirely ceased. America's forests have stabilized at about 750 million acres, one-third of the Nation's land area. A century of forest conservation and restoration has turned America's forests from a net carbon source into a net carbon sink (National Roadmap for Responding to Climate Change). America's forests, including the carbon stored in wood products and landfills, offset about 12 to 16 percent of the carbon dioxide that Americans emitted (U.S. EPA 2012).

Forest regrowth in the United States and the attendant high rates of carbon sequestration, however, have limits, linked as they are to recovery from past deforestation and logging practices. Greenhouse gas accumulations in the atmosphere will have uncertain effects on carbon sequestration. On the one hand, increasing carbon dioxide might accelerate forest growth and carbon uptake; on the other, climate change will exacerbate drought, wildfire, insects, disease, and other disturbances (National Roadmap for Responding to Climate Change).

The National Roadmap for Responding to Climate Change states, "Managing America's forests and grasslands to adapt to changing climates will help ensure that they continue to produce the benefits that Americans need, while helping to mitigate the effects of a changing climate and to compensate for fossil fuel emissions through carbon storage in healthy forests."

Current Carbon Stocks of the Francis Marion National Forest

Existing carbon stocks and changes over time are estimated using Forest Inventory and Analysis (FIA) data, which provides estimates for five pools of carbon within the forest ecosystem. The 2011 estimates for the Francis Marion National Forest total 18.5 teragrams (Tg or million metric tonnes) ± 2.8 Tg of carbon. This represents about 0.04 percent of the total of approximately 45,278 Tg of carbon in forests of the coterminous United States (EPA 2012). The average density of forest carbon is about 71.5 metric tonnes per acre (Mt/ac).

Table 4-1. 2011 Francis Marion National Forest carbon stocks (metric tons)

	By Carbon Pool				
Total Carbon	Above Ground Live Carbon	Below Ground Live Carbon	Dead Wood Carbon	Litter Carbon	Soil Carbon
18,510,684	5,365,790	1,126,540	880,677	908,028	10,229,648

Table 4-2. Proportions of 2011 carbon stocks by forest type and dominant tree size class

	Dominant Tree Size Class			
Forest Type Field Call	Total	Large Diameter (softwood 9 to 19.9;hardwood 11 to 19.9 inches)	Medium Diameter (softwood 5 to 8.9;hardwood 5 to 10.9 inches)	Small Diameter (0.1 to 4.9 inches)
Total	100%	49%	38%	13%
Longleaf pine	11%	8%		2%
Loblolly pine	36%	22%	9%	5%
Pond pine	3%		2%	1%
Loblolly pine/hardwood	6%	3%	3%	
Sweetgum/Nuttall oak/willow oak	13%	4%	9%	
Baldcypress/water tupelo	8%	4%	4%	
Sweetbay/swamp tupelo/red maple	21%	8%	9%	4%
Red maple/lowland	3%		3%	

Harvested Wood Products

Trees harvested from the Francis Marion National Forest are converted to a variety of primary wood products. Sawtimber may be converted partially into lumber that remains in structures for many years. Bark, chips, and sawdust may be used for other products or uses, such as paper or to generate electricity, which given off as emissions over different periods. Landfilled residues and waste are often sequestered for extended periods of time. Forest Service Research has developed methods to estimate the uses of harvested wood and the rates at which the carbon in various products are sequestered or emitted to the atmosphere (Smith et al. 2006).

Annual harvests from the Francis Marion National Forest average 33,132.8 ccf (Forest Service Cut and Sold Reports 2008–2012). On average 0.12 percent of the standing total stocks of carbon are harvested each year. Of this annual harvest it is estimated that more than 30 percent will remain in a sequestered state (wood products in use or in landfills) after 50 years.

Table 4-3. Fate of carbon from annual average forest harvests, Francis Marion National Forest (in metric tons)

Year After Harvest	Total C in Allowable Sales Quantities	C Remaining in Primary Wood Products	Wood Product C Accumulating in Landfills	Total Carbon Emissions	Emitted with Energy Use	Emitted without Energy Use
0	21,843					
10	21,843	7,065	2,493	12,285	7,882	4,403
20	2,843	5,101	3,171	13,572	8,293	5,278
30	218	4,206	3,431	14,206	8,420	5,786
40	218	3,582	3,606	14,654	8,477	6,178
50	218	3,116	3,741	14,986	8,491	6,495

Carbon Emissions in Smoke

The Francis Marion National Forest has an active prescribed burning program, with an average of 35,000 acres burned annually. These emissions represent a small fraction of the total carbon stocks on the Forest as well as the carbon estimates in available fuels. Annual prescribed burning emits carbon at the rate of about 8.4 percent of the carbon in down wood and litter, but only 0.8 percent of the total standing carbon stocks. Prescribed burning generates GHG emissions other than carbon as methane and nitrogen oxides. Estimates of these emissions and comparisons of their effects as carbon dioxide equivalents are presented in Table 4-3.

Forest-level Annual GHG Emission Calculator

GHG GAS	EMISSION FACTOR (lb/metric ton)	EMISSION FACTOR (lbs/U.S. ton)	FUEL CONSUMPTION (tons/acre)*	ACRES BLACKENED (acres)**	TOTAL EMISSIONS (lbs)	TOTAL EMISSIONS (metric tons)	CO2 Equiv. (metric tons)
CARBON DIOXIDE - CO2	3,457.00	3,137.00	3.00	35,000.00	329,385,000.00	149,409.04	149,409.04
METHANE -CH4	11.90	10.80	3.00	35,000.00	1,134,000.00	514.38	10,802.03
NITROGEN DIOXIDE -N2O	0.46	0.42	3.00	35,000.00	44,100.00	20.00	6,201.17

Figure 4-3. Francis Marion National Forest emissions from annual average prescribed burning

Total Emissions

Table 4-4 shows total GHG emissions during 2009 (includes land use change).

Table 4-4. Total GHG emissions 2009 (includes land use change)

	Million Mt CO2e	% of U.S. Total
U.S.	5, 209.70	100.00
Region 8 State Totals	2,003.1	38.45
South Carolina	50.5	0.97
Francis Marion NF	0.79	0.02

Recent Carbon Stock Trends of the Francis Marion National Forest

Forest carbon stocks fluctuate over time as the forest grows and goes through varying levels of impact from disturbance. When the Francis Marion National Forest was established, the land had been heavily cut over. Some of the land had been rained and cultivated for agriculture. Reforestation, fire protection, and limited harvests provided for regrowth of the forest and large accumulations of carbon stocks. On September 21, 1989, Hurricane Hugo struck the South Carolina Coast, causing extensive damage to the forest. FIA inventories reflect the impacts from early growth through the disruption Hurricane Hugo to the recent period of recovery.

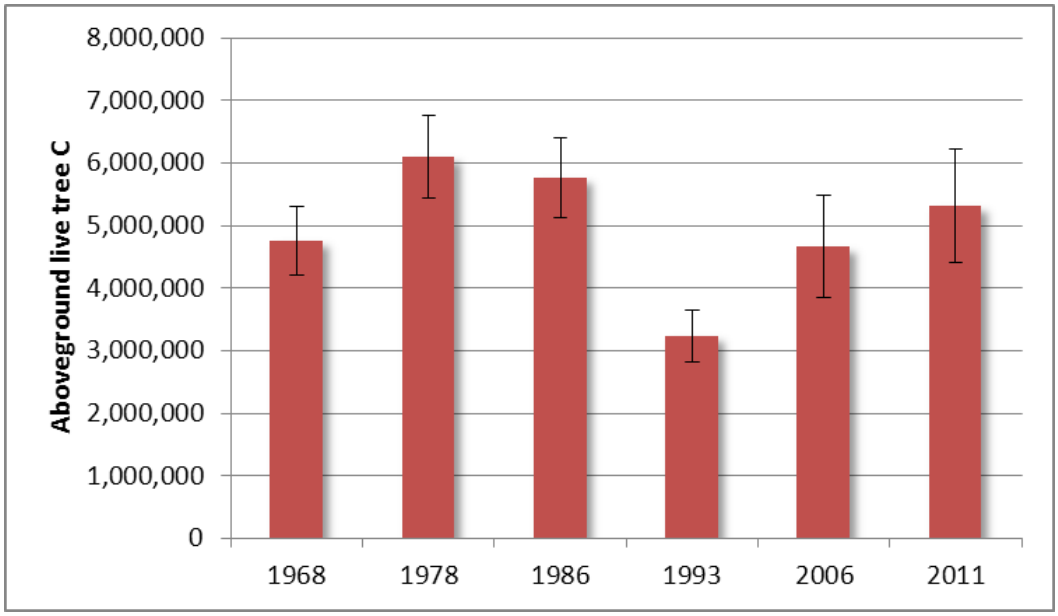


Figure 4-4. Total above ground live carbon stock estimates for the Francis Marion National Forest, 1968–2011

The Francis Marion National Forest was a source of carbon into the atmosphere in the short period after Hurricane Hugo. For the most recent two decades the Forest has been and continues to be a large carbon sink, sequestering large amounts of carbon through forest growth. The most recent inventories indicate that the Francis Marion National Forest is a carbon sink, with most recent 5-year accumulations at the rate of about 14 percent. Although this increase is within the sampling error for the inventory, the trends reflect that a continued increase at this rate is likely. These estimates include the growth, mortality, and harvests. Even considering the current harvest and burning levels the Forest maintains large carbon stocks that continue to grow.

5 Threatened, Endangered, Proposed and Candidate Species, and Potential Species of Conservation Concern Present in the Plan Area (At-Risk Species)

5.1.1.1 Summary of Key Findings – At-Risk Plants

►**We are identifying lists of at-risk species and evaluating plan area ecological conditions for these species in the plan area. The set of at-risk species evaluated within this assessment includes:**

1) Federally recognized threatened, endangered, proposed and candidate species.

2) Potential species of conservation concern. The planning rule requires that species of conservation concern be "known to occur in the plan area" and that the regional forester ultimately identify "species of conservation concern", for which "the best available scientific information indicates substantial concern about the species' capability to persist over the long term in the plan area".

►**The 1996 Revised Forest Plan addressed 38 proposed, threatened, endangered, and sensitive species, including 3 mammals, 8 birds, 3 amphibians, 4 reptiles, and 20 plants, and suggests that conditions would be provided for them, and in some cases, the species would be thriving.** Of the 20 plants included as proposed, threatened, endangered, and sensitive species in the 1996 Revised Forest Plan, all are being addressed as "at-risk" species in this 2013 assessment, with the exception of one plant species that is not known to occur on the Forest—Carolina least trillium (*Trillium pusillum*).

►**A list of 75 at-risk plants including 3 federally listed species and 72 "potential species of conservation concern" has been identified as of 10/30//2013.** The list of the 72 species of potential conservation concern are included in Appendix A, including their ranks and the number of known occurrences on the Forest. These lists are based on a review of federally listed and at-risk species identified by USDA and NOAA, state and globally ranked plant species lists maintained by South Carolina Department of Natural Resources Heritage Program; and by Natureserve, species expert opinion, rare species records for the Forest, and a review of the proposed, threatened, endangered, and sensitive species list addressed in the 1996 Forest Plan.

►**Numbers of federally endangered American chaffseed (*Schwalbea americana*) plants declined by 60 percent between 2001 and 2008, and declines are associated with a lack of frequent, 1- to 3-year fire regimes, particularly in the wildland-urban interface.** We have 4 populations and as many as 20 occurrences for American chaffseed on the Forest in 2013, occurring primarily along roadsides. We are restoring nine populations off roadsides and into the adjacent upland longleaf pine stands. We are enhancing the genetics of some of our populations using seed from populations occurring on nearby private lands.

►**Several new occurrences for the federally endangered pondberry (*Lindera melissifolia*) were discovered, but are threatened by competition with woody shrubs at depression pond ecotones, and few populations are producing fruit.** We have 5 natural populations for pondberry on the Forest, including at least 24 occurrences, and 2 experimental populations.

Three populations have been enhanced with genetic material, one recently, and two in the late 1970s. Information on management needs for this species has evolved from protection of colonies to careful management (Glitzenstein 2007; Gustafson 2012; Lockhart et al. 2013).

►**One confirmed occurrence for the federally endangered Canby's dropwort (*Oxypolis canbyi*) was discovered from a pond cypress savanna depression pond in 2000, but no plants have been observed on the Forest since 2006. This decline is in part associated with successional vegetation and lack of frequent prescribed fire in the wildland-urban interface.** In a species status survey in 2006 (USDI), Gaddy describes the habitat in this pond as excellent. More recent monitoring describes threats from successional woody vegetation (Glitzenstein 2012).

►**In 2013 the Forest Service began enhancing and restoring populations for American chaffseed, pondberry, and Canby's dropwort at known and historic sites, where management strategies alone had failed, and genetic bottlenecks were likely limiting sexual reproduction (USDI 2013; Gustafson 2012; Echt et al. 2011).**

►**The 75 at-risk plant species were grouped by the primary ecosystem or species group with which they are associated in Appendix A, for the purposes of identifying ecological conditions, drivers, and threats.** Of 74 at-risk plant species, 26 are associated with Pine Woodland and Savanna Ecosystems, including 5 in dry to mesic Upland Pine Woodlands, and 21 in mesic to wet Pine Savannas (including Marl Savannas); 20 are associated with Pond Cypress Savannas and Herbaceous Meadows (associated with Carolina Bays and Depression Ponds), 4 occur in Non-Riverine Swamp and Wet Hardwood Forests, 4 in Calcareous Mesic Slope Hardwood Forests, 8 in Calcareous Blackwater Stream and River Floodplain Forests, 3 in Marl Outcrops or in Maritime Shell Forests, and 10 in Seepage Slopes, Pocosins, and Non-Riverine Swamp Ecotones.

►**Twenty-one at-risk plant species occur in Pine Savannas and Flatwoods including Wet Marl Savannas, making this the largest at-risk plant species group.** Several species in this group are in decline, particularly those occurring in the wildland-urban interface (*Sporobolus curtisii*, *Sporobolus pinetorum*, *Platanthera integra*, including Awendaw and Gumville savannas).

5.1.1.2 Changing Conditions

The 1996 Revised Forest Plan lists 38 proposed, threatened, endangered, and sensitive species in the Forest monitoring report, including 3 mammals, 8 birds, 3 amphibians, 4 reptiles, and 20 plants, and suggests that conditions will be provided for them and in some cases, they would be thriving. In many cases, that has not occurred.

The new Forest planning regulations specify a focused coarse-filter/fine-filter approach which also takes into account the species rarity on the unit and the inherent capability of the plan area. Consistent with the Forest planning regulations, as part of this assessment, we are including consideration of lists of at-risk plant, animal, and aquatic species, and are evaluating plan area ecological conditions. The set of at-risk species for assessment planning purposes include:

1) Federally listed threatened, endangered, proposed and candidate species; and

2) *Potential* species of conservation concern. Ultimately, species of conservation of concern will be identified to include those species "known to occur in the plan area" and for which the regional forester has identified that "the best available scientific information indicates

substantial concern about the species' capability to persist over the long term in the plan area".

5.1.1.3 Information Provided by Interested Parties

We consulted with both USDI Fish and Wildlife Service (USFWS) and National Oceanic and Atmosphere Agency (NOAA), and obtained lists of federally listed species occurring in both Berkeley and Charleston counties from agency web sites, as directed by the Charleston Ecological Services Office of the USFWS on June 6, 2013, and the Saint Petersburg, Florida, office of NOAA, Fisheries Division, on July 22, 2013.

Lists of at-risk species identified on USFWS county lists were included as species of potential conservation concern, and were reviewed based on likelihood of encountering these species on national forest lands.

Species groups were identified by considering information on ecological conditions for at-risk plants, including stresses, threats, ecosystem or plant community associations; and consulting species experts, local floras, rare plant databases and associated monitoring information; and forest and species monitoring reports for the Forest (Carlson 2012; Glitzenstein 2012; Everett 2012; Weakley 2010; Gramling 2003; McMillan et al. 2001; Porcher 1996).

5.1 Federally Listed Threatened, Endangered, Proposed, and Candidate Species – Plants

American Chaffseed (*Schwalbea americana*)

Past and Likely Future Trends

The 1996 Revised Plan, page 5-7, stated that 11 populations for American chaffseed occurred on the Forest and contained as a standard FW-86, to [I]dentify potential locations of suitable habitat for both American chaffseed and pondberry and manage those sites as possible locations for out-planting and establishing new populations. If we use Natureserve's Habitat-based Plant Element Occurrence delimitation guidelines to differentiate populations from occurrences (2004), we have 4 existing American chaffseed populations, of 9 populations and 20 occurrences once documented (see Table 5-1). Numbers of American chaffseed plants on the Forest declined by 40 percent between 2001 and 2008, and three populations have likely been lost (Ballfield, Highway 41, and Cordesville). Those that occur at low numbers or have not been observed in several years occur in the wildland-urban interface.

Several studies and monitoring efforts document the dependence of American chaffseed on frequent prescribed fire regimes (Kirkman et.al. 1998; Streng and Glitzenstein 2004). In the 1996 Revised Plan, all American chaffseed occurrences were included in management area 26, which was dedicated to Longleaf Ecosystem restoration and contained a standard to prescribe burn this management area on a 2- to 3-year rotation. Due to smoke management and public safety concerns in the wildland-urban interface, only 34 percent of this management area was prescribed burned on at least a 3-year rotation between 2004 and 2012.

The following shows American chaffseed trends using data collected in May or June of each year, with the exception of 2013, when it was collected later in the season.

Table 5-1. American chaffseed monitoring trends, Francis Marion National Forest

		Year Monitored*						
Population	**Site**	**1999[1,2]**	**2001[1,2]**	**2004[1,2]**	**2008[1,3,4]**	**2010[1,3,4]**	**2012[4,5,6]**	**2013[1**]**
C.115 - Hwy. 41	#17	3	3[2,3,4]	3	0[4]	0	0	0
C.192 - Ballfield	#18	9	4[3,4]	2	0[4]	0	0	0
C.107 - French Quarter Creek Road	#07, Interior	47	21[3,4]	22	4[4]	2	3	4
	#30, Near Road	0	NM	0	0	0	0	0
C.204 - Lethcoe Road	#63	35	26[3,4]	64	33[4]	25	22	19
C.196/205 – Halfway Creek Road	All	364	420	132	145	102	163	166
	C.196, North Side	59	90[3]	31	42[4]	32	25	23
	NW 5139	44	10[2]	15	17[3]	8	3	0
	C.205, South Side	214[1,3,4]	283[2,3,4]	63	62[4]	42	73	80
	C.205, Cypress Pond	37	37[3]	12	113	14	52	49
	C.205, Hiking Trail	10	NM	11	133	6	10	11
C.80/C.87 Witherbee Road	All	467	770	581	298	276	366	300
	C.80, Reserve					11	3	0
	C.80, Reserve					96	42	50
	C.80, Hellhole					100	75	59
	C.87, Reserve					40	59	
	C.87, Roy's Place (Experimental)	0	0	37	19[2]	0	0	3
	C.88, Hellhole					29	187	153
	C.79/88 (Ackerman)					0	0	0
C.90 – Cordesville	Last observed on NFS land in 1985	10	NM	1	0[4]	0	0	0
C.111- Harleston Dam	Last observed 1979							0
C.130 - Mill Branch	Last observed 1974							0
Grand Total - #Plants		**935**	**1,244**	**842**	**499**	**405**	**554**	**489**

*Monitoring conducted by Jeff Glitzenstein[1], Donna Streng[2], Danny Carlson[3], Robin Mackie[4], Mark Danaher[5], and Ricky Wrenn.[6]

**Monitoring in 2013 conducted late in season.

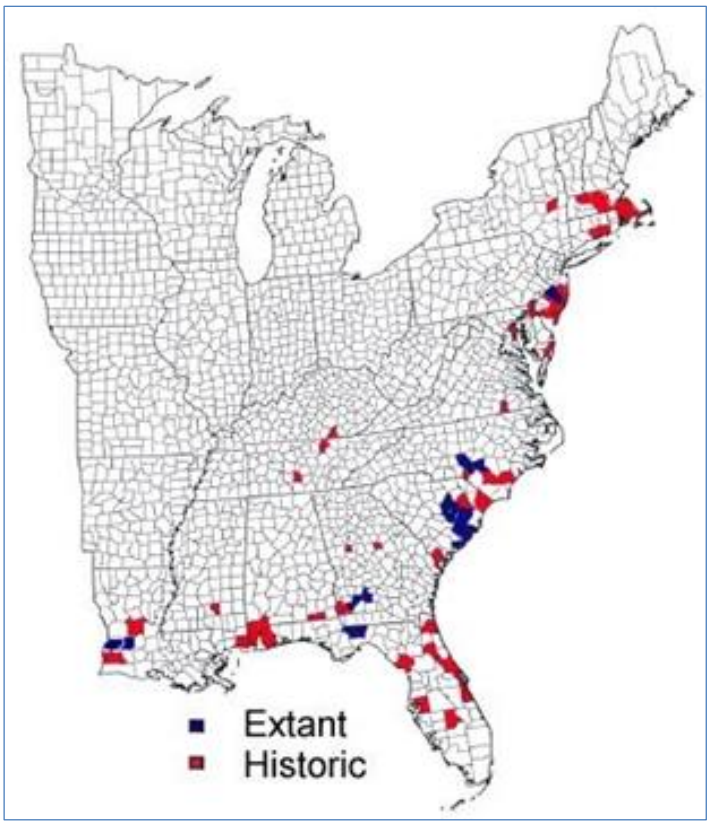


Figure 5-1. Range of American Chaffseed (USDI)

In 2013 the Forest Service began enhancing and restoring populations for American chaffseed, pondberry, and Canby's dropwort at known and historic sites, where management strategies alone had failed, particularly where genetic bottlenecks were likely limiting sexual reproduction (USDI 2013; Gustafson 2012; Echt et al. 2011). Recovery plans emphasize that first priority be given to management and enhancement of populations at known and historic sites for the species, where possible. Norden and Kirkman (1998) suggest that the species can go through periods of "dormancy" in the absence of frequent prescribed fire or during periods of drought; we have experienced long-term drought during the planning period. However, small, isolated populations exhibit low levels of population differentiation, and are highly vulnerable to extirpation, particularly given climate change predictions. Given the plant's dependence on frequent fire, the location of several sites in the wildland-urban interface, and semi-parasitic growth habit resulting in low levels of survival in the field, as well as difficulties in detection and monitoring, it is likely that this species will always be rare and vulnerable to extirpation throughout its range. Establishment and enhancement of known and historic populations through propagation and improved management techniques could lead to population increases in the future.

Broader Landscape

Recovery criteria include "[B]iennial monitoring shows that 50 protected populations are viable as well as stable or increasing over a 10-year period", and "[L]ong-term protection is achieved for 50 geographically distinct, self-sustaining populations." The USFWS conducted a 5-year review for American chaffseed in 2010, and identified 1 site each in Alabama, Florida, and Lousiana, 2 in New Jersey, 11 in North Carolina, and 33 in South Carolina. Destruction and

adverse modification of habitat through development and incompatible agriculture and silviculture practices and herbivory are major threats to the species (USDI 1995, 2010).

In South Carolina, several large populations for American chaffseed occur on private lands managed for bobwhite quail in Williamsburg County. One population occurs at Lynchburg Savanna Heritage Preserve, where optimal habitat is sandy, open-canopied Longleaf Pine Flatwoods, maintained with frequent, 1- to 3-year prescribed fire.

Pondberry (*Lindera melissifolia*)

Past and Likely Future Trends

The 1996 Revised Plan stated that 9 populations of pondberry occurred on the Forest, and set a goal for 14 (page 5-7). Based on long flight distances of ground-dwelling bees that pollinate pondberry, a more recent definition of a pondberry population is "colony or colonies separated by at least one mile from other colonies" (Devall et al. 2001; USDI 2007). Given this definition, the Francis Marion harbors five natural populations for pondberry in 2013, plus one population that has been introduced (French Quarter Creek Road). Recovery plans emphasize that first priority be given to management and enhancement of populations at known and historic sites for the species, where possible. Since 1996, 11 new occurrences for the plant have been found, and as of 2010, at least 9 of those contained 200 to 1,000 stems, though little fruit reproduction has been observed (Gustafson 2012; Glitzenstein 2004). As of 2013 there were 24 documented occurrences on the Forest (Forest GIS and monitoring data).

Information on management needs for this species has evolved from protection of colonies to careful management (Glitzenstein 2007; Gustafson 2012; Lockhart et al. 2013). All pondberry occurrences were included in either management area 26, dedicated to Longleaf Ecosystem restoration, or within designated botanical areas in the 1996 Revised Plan. Notable declines in pondberry have occurred since 1996, particularly at the Honey Hill population, where it was protected from management. This site previously harbored the largest concentration of pondberry in South Carolina. Declines at the Honey Hill population have been reversed by more active management, to opening the canopy, restoring Longleaf Pine Savannas, and prescribed burning into the ecotone of the ponds (Glitzenstein 2007).

Under the guidance of Gustafson (2012) we are addressing our lack of fruit production, and have enhanced two of our pondberry populations on the Forest, one with female plants (Hoover-Brick Church-Highway 41) and the other at Echaw Road with both males and females (this population had declined to less than ten stems). Although laurel wilt occurs on the Forest and is a threat to species in the Lauraceae, we have confirmed that pondberry stems are too small to be infected.

Broader Landscape

As of 2007 there were 54 potential populations in the region for pondberry; these include Alabama (2), Arkansas (19), Georgia (7), Mississippi (16), Missouri (1), North Carolina (2), and South Carolina (7).

According to the Recovery Plan (1993), pondberry may be downlisted as threatened when 15 self-sustaining populations are protected, and delisted with the permanent protection of 25 self-sustaining populations.

Canby's Dropwort (*Oxypolis canbyi*)

One population containing ten plants for Canby's dropwort was confirmed from a Depression Pond containing a Pond Cypress Savanna in 2000. Only one plant was located by Gaddy in

2006 (USDI 2006), who described the habitat (Tibwin Cypress Savanna) as excellent. No plants have been relocated at this site, or at another unconfirmed, Pond Cypress Depression (Gramling 2003).

Glitzenstein (2012) found that the Tibwin pond was impacted by succession and the Pond Cypress Depression with the unconfirmed occurrence, by succession and by feral hogs, though Tibwin Cypress Savanna, which occurs in the wildland-urban interface, was prescribed burned by the Forest Service in 2011. Climate change could jeopardize the existence of isolated populations in the future which are more likely to have low genetic diversity to adapt to change. This species is likely to continue to be rare and threatened both on the Forest and throughout the range of the species in the future.

Broader Landscape

In the 5-Year Species Review (2010a), the USFWS concluded that eight sites for the species are currently managed and protected, including five in South Carolina (Tibwin Savanna on the Francis Marion National Forest, Monkey Meadow Bay in Clarendon County, Crosby Oxypolis Heritage Preserve in Colleton County, Longleaf Pine Heritage Preserve in Lee County, and Lisa Mathews Bay in Bamberg County), three sites in Georgia, and one in Maryland.

The recovery goal is that at least 14 sites are currently extant self-sustaining populations and that necessary management actions are being undertaken by landowners to ensure their continued survival. The most significant threat to the species is loss or alteration of rare wetland habitat (USDI 2010), though on sites that are not actively disturbed by logging, ditching or dredging, the plant will respond well to management which limits the encroachment of shrubs or trees that increase evapotranspiration, lower the water table, and shade-out Canby's dropwort (USDI 2010).

5.2 Potential Species of Conservation Concern – Plants

5.2.1.1 Past and Likely Future Trends

Appendix A has a complete list of all at-risk plants identified as of August 1, 2013, along with global, state, and unit ranks, and the number of documented occurrences on the Forest (based on state heritage, Forest threatened, endangered, and sensitive plant GIS data). For the purposes of analysis of ecological conditions and trends, including stresses, threats, and key ecosystem characteristics, at-risk plant species were grouped by ecosystem or species group (Appendix A). A summary of the status of each ecosystem or species group with explanations of key ecosystem characteristics, and stressors or threats, which weigh most heavily in determining current condition and trends is given below, linked to terrestrial ecosystems as described in Section 1 of the assessment, and included in Appendix A.

Non-Riverine Swamp and Wet Hardwood Forest Species

Four at-risk plant species are associated with Non-Riverine Swamp and Wet Hardwood Forests. The 1996 Revised Plan included climbing fetterbush as a sensitive species, but did not include the other species addressed in this group. Several occurrences and three populations for climbing fetterbush occur on the Forest growing on pond and bald cypress, and two are extensive and stable as of 2012, occurring in cypress stands older than 100 years (Everett 2012; Carlson 2012, personal comment). Although climbing fetterbush is associated with older cypress gum swamps, the other three species may be found in Bottomland Hardwood and Mixed Pine-Hardwood Forests.

Calcareous Mesic Slope Hardwood Forest Species

Four at-risk plant species are associated with a limited number of high calcium mesic slope communities on the FMNF and outer coastal plain of South Carolina (McMillan et al. 2001; Porcher 1991; Everett 2012). None of the four at-risk plant species identified was addressed on the proposed, threatened, endangered, and sensitive species list included with the 1996 Revised Forest Plan. The 1996 Revised Forest Plan included the conservation of select high calcium communities as designated botanical areas and also contained as an objective, to "Identify and maintain existing acreage in coastal plain calcareous mesic forest". New high calcium plant communities, providing habitat for potential species of conservation concern were identified by McMillan et al. (2001) and are being delineated by Everett (2012).

Calcareous Blackwater Stream and River Floodplain Forests

Eight at-risk species are associated with high-calcium blackwater stream and river floodplain forests (Appendix A). None of the plant species in this group were addressed as proposed, threatened, endangered, and sensitive plant species in the 1996 Revised Forest Plan, though some occurred within designated botanical areas (McMillan et al. 2001; Porcher 1991; Everett 2012). New high calcium plant communities, providing habitat for potential species of conservation concern were identified by McMillan et al. (2001) and are being delineated by Everett (2012).

Marl Outcrop and Maritime Shell Forests

Three at-risk plant species are associated with Marl Outcrops and Maritime Shell Forests (Appendix A). All three plant species were addressed as proposed, threatened, endangered, and sensitive species in the 1996 Revised Plan, and some occur within designated botanical and scenic areas in the 1996 Revised Forest Plan. Neither of the spleenworts has been observed in recent years (Everett 2012), though tiny-leaved buckthorn remains stable at Sewee Shell Mound, where recreation use, invasive plant species, and sea level rise have the potential to impact the species.

Pond Cypress Savannas and Herbaceous Meadows (associated with Carolina Bays and Depression Ponds)

Twenty at-risk plants are associated with this species group (Appendix A). Six plant species were on the proposed, threatened, endangered, and sensitive species list addressed in the 1996 Revised Forest Plan, including two federally listed plants. Awned meadow beauty was a management indicator species. Several new records for both pondspice and awned meadow beauty have been discovered on the Forest since 1996 (Gramling 2003; Gramling and Gramling 2010; Glitzenstein 2012). Several high quality Pond Cypress Savannas and Herbaceous Meadows containing at-risk plant species were designated botanical areas, of which some have documented declines such as, beakrushes at Florida bay, pondberry at Honey Hill, Canby's dropwort at Tibwin Bay, and Boykin's lobelia at Echaw Road Bay, Tibwin Bay, and McConnell Sink (see Appendix A). Most declines are associated with lack of frequent prescribed fire, succession by woody species; some are associated with illegal ATV use.

Seepage Slopes, Pocossins, and Fire-Maintained Non-Riverine Swamp Ecotones

Ten at-risk plant species are included in this species group (Appendix A). Only spoonflower was included on 1996 proposed, threatened, endangered, and sensitive species list, and sweet pitcher plant was included as a management indicator species. Several new records for sweet pitcher plant have been located on the Forest since 1996, though monitoring specific to sweet pitcher plant suggests that this species has undergone declines since 1996, as a result of illegal poaching, roads or road maintenance, lack of frequent prescribed fire, drought, feral hog damage, and

rutting associated with illegal ATV or past land use (Everett 2012; Glitzenstein 2012). Select Pocossins or Pocossin Vegetation and Seepage Bogs containing populations for at-risk plants occur as designated botanical/natural areas (such as, Morgan Creek Bog, Halfway Creek Pocossin). Declines have been noted in regard to successional vegetation, plant poaching, and lack of frequent prescribed fire.

Dry to Mesic Phase Upland Longleaf Pine Woodlands

Five at-risk plant species occur in this species group (Appendix A), of which three were included on the 1996 proposed, threatened, endangered, and sensitive species list. Monitoring specific to at-risk species in this group suggests that high pine canopy, and lack of frequent prescribed fire (1- to 3-year burning regime) are primary threats to this group (with the exception of incised groovebur), particularly in the wildland-urban interface. One species is a crested plume orchid, which could be threatened by illegal plant collections, but also exhibits annual population fluctuations, and is therefore difficult to monitor.

Mesic to Wet Phase Longleaf Pine Savanna and Flatwoods (including Wet Marl Savannas)

Twenty-one at-risk plant species occur in this species group, including four that are associated with Wet Marl Savannas (Appendix A). Two of these plant species were addressed as proposed, threatened, endangered, and sensitive species in the 1996 Revised Forest Plan (*Asclepias pedicellata*, *Platanthera integra*). This is the largest at-risk plant species group. Monitoring of current sensitive species in 2012 has shown that several species in this group are in decline, particularly those in the wildland-urban interface (*Sporobolus curtisii*, *Sporobolus pinetorum*, *Platanthera integra*, including those in the Awendaw and Gumville savannas). Some Wet Pine Savannas were included as designated botanical areas in the 1996 Revised Forest Plan (such as, Awendaw savanna), but many were not. Most all species are threatened by successional woody vegetation, lack of frequent prescribed fire, and overly dense canopies—which can play a role in both shading and modifying the site hydrology.

5.2.1.2 Information Needs

1) Ecological conditions for at-risk plant species—management needs and monitoring responses.

2) Trends and distribution of select at-risk plant species populations.

5.2.1.3 Levels of Uncertainty

Uncertainty will always exist in predictions of future trends for rare species, their distribution, rarity, management responses, and threats and stresses.

5.3 At-Risk Terrestrial Wildlife

5.3.1.1 Findings

►We are identifying lists of at-risk species and evaluating plan area ecological conditions for these species in the plan area. The set of at-risk species evaluated within this assessment includes:

1) Federally recognized threatened, endangered, proposed and candidate species.

2) Potential species of conservation concern. The planning rule requires that species of conservation concern be “known to occur in the plan area” and that the Regional Forester ultimately identify “species of conservation concern”, for which “the best available scientific

information indicates substantial concern about the species' capability to persist over the long term in the plan area".

►The 1996 Revised Forest Plan addressed 38 proposed, threatened, endangered, and sensitive species, including 3 mammals, 8 birds, 3 amphibians, and 4 reptiles, and suggests that management direction would provide necessary habitat conditions for them.

►The USFWS oversees the enforcement of the Endangered Species Act (ESA), and is responsible for working with the Forest Service to provide habitat on for threatened, endangered and proposed species on national forest lands.

►In 2003 the USFWS updated the red-cockaded woodpecker recovery plan. The size and health of the population indicates that the red-cockaded woodpecker might not need the specific pine tree size and age requirements for its foraging as indicated in the red-cockaded woodpecker recovery plan. The biggest difference between the Forest plan and the 2003 red-cockaded woodpecker recovery was that the Forest plan had more intensive monitoring requirements.

- Since 2007, the Francis Marion National Forest's red-cockaded woodpecker population has exceeded the recovery goal of 350 potential breeding groups as described in the Recovery Plan for the Red-cockaded Woodpecker (*Picoides borealis*) Second Revision (Red-cockaded Woodpecker Recovery Plan).
- Over a third of the red-cockaded woodpecker clusters on the FMNF have foraging at or below the managed stability standard, yet the population continues to grow naturally. Although so many clusters on the FMNF do not meet the recovery standard or managed stability standard, the bird is thriving within the areas that are burned on a 2- to 3-year interval (referred to as the "core burn area" on the FMNF (see Figure B-3 in Appendix B for a map depicting the core burn area).

►The 1996 Francis Marion Forest Plan addresses management of habitat for of red-cockaded woodpecker, red-cockaded woodpecker populations have grown, and new information is available.

- Due to aggressive habitat management and installation of over 2,800 artificial cavities, the red-cockaded woodpecker population has rebounded to approximately 439 active clusters as of January 1, 2013 (Table 5-2 and Appendix B, Figure B-1).
- The long-term objective for red-cockaded woodpecker in the 1996 Forest Plan is 450 active clusters (page 2-2 in the Francis Marion forest Plan). However, red-cockaded woodpecker management will continue to be needed for many years to come (e.g., artificial cavity installation and replacement, mechanical midstory control and annual monitoring).

►The 1996 Forest Plan does not address critical habitat for frosted flatwoods salamander. Critical habitat (1,176 acres on the FMNF) was designated for the frosted flatwoods salamander during 2008. In terms of the frosted flatwoods salamander, only 8 adults and approximately 12 larvae have been captured on the Francis Marion in the past 20 years. (Harrison 2004, 2005; Palis 2009). Nineteen wetlands were surveyed during 2010, and *Ambystoma cingulatum* was documented on the Forest for the first time since 2003. Six larvae were collected from a previously undocumented breeding wetland during March 2010.

►**Prescribed burning is the most important, cost-effective management tool to maintain critical habitat for federally listed species, such as the red-cockaded woodpecker and frosted flatwoods salamander.** The Francis Marion red-cockaded woodpecker population is expanding in some areas of the Forest, especially in areas that are consistently burned on a 2- to 3-year return interval. Areas that have been consistently burned on a 2- to 3-year return interval are commonly lumped together and referred to as the core burn area (Figure B-3). There are some areas on the FMNF where clusters are becoming inactive or reduced to "single bird groups". These clusters tend to be concentrated in the wildland-urban interface and/or areas where minimal forest management has allowed undesirable midstory succession to occur (Figure B-4).

►**The federally endangered (*Trichechus manatus*) West Indian manatee has been documented in the waters of Berkeley and Charleston, but the Francis Marion National Forest does not occur in the area covered by the 2001 recovery plan (USFWS 2001).** The West Indian manatee lives in freshwater, brackish, and marine habitats. Submerged, emergent, and floating vegetation are their preferred food. During the winter, cold temperatures keep the population concentrated in peninsular Florida and many manatees rely on the warm water from natural springs and power plant outfalls. During the summer they expand their range and on rare occasions are seen as far north as Rhode Island on the Atlantic coast and as far west as Texas on the Gulf coast.

►**The Federally listed *Mycteria americana* wood stork has been documented on the Forest, but it is not addressed in the 1996 Francis Marion Forest Plan.** From the 1960s to the mid-1980s, the wood stork nesting population declined in southern Florida and increased in northern Florida, Georgia, and South Carolina. Prior to 1970, a majority (70 percent) of the population nested south of Lake Okeechobee and declined from 8,500 pairs in 1961 to fewer than 500 pairs in the late 1980s and early 1990s. During the same period, nesting in Georgia increased from 4 to 1,501 pairs and nesting in South Carolina increased from 11 to 829 pairs (USFWS 2007). This extended the breeding range north along the coastal plain of Georgia and South Carolina. Overall, surveys between 1983 and 1995 documented a population in the Southeast U.S. ranging between 4,073 and 7,853 pairs.

►**In 2007, the American bald eagle was de-listed as a federally endangered species, but it is still protected by the Bald and Golden Eagle Protection Area and has been included as a potential species of conservation concern.**

►**The 1996 Forest Plan direction includes standards to protect American swallow-tailed kite, but new information is available on this species.** There are concerns about the impact of prescribed burning on the species during the nesting season. The use of aerially ignited prescribed burns during the swallow-tailed kite nesting season is a biological concern. This concern is mainly tied to the intensity of burning that sometimes takes place in prime swallow-tailed kite nesting habitat (e.g., ecotones and floodplains of streams). Swallow-tailed kite numbers on the Francis Marion National Forest have remained fairly constant since Hurricane Hugo. However, preliminary nesting data since 2004 indicates that nesting success may be decreasing on the FMNF

►**Carolina gopher frog (*Lithobates capito*) is one of the rarest amphibians on the Forest.** The Carolina gopher frog is currently a state endangered species in South Carolina with a natural heritage rank of S1 (NatureServe 2005). The USFWS has been petitioned to list it under the Endangered Species Act.

►Some potential species of conservation concern are included, although they have not been recorded on the FMNF in the last 10 to 15 years. The status of Rafinesque's big-eared bat (*Corynorhinus rafinesquii*) and southeastern myotis (*Myotis austroriparius*), is unknown because these species are extremely difficult to monitor.

►In terms of habitat concern, the Wando Area is likely the number one area on the FMNF, as it supports some of the highest densities of potential species of conservation concern on the FMNF. Increased urbanization and human population growth are significant concerns within the planning area, especially in terms of the negative impacts they pose to at-risk species and forest management. In terms of habitat concern, the Wando Area is likely the number one area on the FMNF to be concerned about during the next 10 to 15 years, as it supports some of the highest densities of proposed, endangered and Forest sensitive species on the FMNF. The Wando Area supports one of the last remaining frosted flatwoods salamander populations in South Carolina, and some of the highest concentrations of Carolina gopher frog breeding wetlands in the state. In fact, all known *A. cingulatum* occurrences on the FMNF only occur in the Wando Area.

►Hurricanes will always be a potential threat to the red-cockaded woodpecker on the FMNF. Since 1700, there appear to have been about 18 hurricanes that probably affected the FMNF (Langley and Marter 1973; Calhoun 1983; USACE 1986; Neumann et al. 1987; Hooper 1990). These data suggest the FMNF is subjected to hurricane-force winds about once every 16 years. The red-cockaded woodpecker now exists in habitat islands spread out along the Atlantic and Gulf Coast states. As such, hurricanes are a menace to the species. Although the red-cockaded woodpecker population has rebounded to historically high numbers, the Francis Marion National Forest will have to continue aggressive habitat management and monitoring for many years to come. As long as there are no catastrophic events, it is anticipated that the artificial cavity program will continue to be needed until there are vast amounts cavity-size pines in suitable habitat for the red-cockaded woodpecker. This may take as long as 40 years due to Hurricane Hugo's destruction. There are some areas on the FMNF where red-cockaded woodpecker clusters are becoming inactive or reduced to single bird groups. These clusters tend to be concentrated in the wildland-urban interface and/or areas where minimal forest management has allowed undesirable midstory succession to occur.

►Roads can have significant adverse ecological and biological effects on amphibians and reptiles, as well as numerous other faunal groups. Some heavily traveled paved roads on the FMNF cause significant amphibian and reptile mortality (these include, Highway 17, Highway 41, Highway 402, Highway 45, and Steed Creek Road). As the human population continues to increase in the counties of Berkeley, Charleston, and Dorchester, wildlife road mortality is expected to continue to increase as more vehicles are on the roads. Road impacts on wildlife need to be assessed on the FMNF in order to identify potential mitigation measures.

►Many isolated wetlands on the Francis Marion have been negatively impacted by past land practices and are in need of restoration. These wetlands provide some of the best and only available breeding habitat for species such as the frosted flatwoods salamander and Carolina gopher frog.

►Personal communications with Julian Harrison in 2006 and 2007, who had detailed knowledge of the FMNF herpetofauna, indicated that one of the biggest changes to frosted flatwoods salamander and Carolina gopher frog breeding wetlands on the FMNF since the 1950s was hardwood shrub and tree encroachment both within the wetland ecotones and

the wetlands themselves. Changes in vegetation like this can significantly degrade breeding wetlands for species such as *A. cingulatum* and *L. capito*.

▶Important changes that have occurred since 1996:

1. Expansion of the red-cockaded woodpecker population with active management, primarily through prescribed burning and thinning.
2. Delisting of the American bald eagle.
3. Change in status of the American alligator.
4. Identification of critical habitat for the frosted flatwoods salamander.
5. Management emphasis shifting to incorporate restoring hydrologic regimes.
6. Rapid urban development of the Mount Pleasant Wando area and along Highway 17 in North Charleston County.

5.3.2 Threatened, Endangered, Proposed and Candidate Species

We consulted the USFWS and the National Marine Fisheries Service in preparing a list of federally listed terrestrial wildlife species for this assessment. A condensed list of threatened and endangered species from those two sources appears in Table 5-2.

Although other species may and have been found on or near the Forest, the frosted flatwoods salamander and red-cockaded woodpecker are the only threatened, endangered, or candidate species that are known to have critical habitat on the Francis Marion National Forest.

Table 5-2. Threatened, endangered, proposed and candidate species considered in the 2013 assessment of the Francis Marion National Forest

Category	Common Name	Scientific Name	Status*	Global Rank	Critical Habitat
Amphibian	Frosted Flatwoods Salamander	*Ambystoma cingulatum*	T	G2	yes
Amphibian	Carolina Gopher Frog	*Lithobates capito capito*	Petitioned for federal listing		yes
Bird	Red-cockaded Woodpecker	*Picoides borealis*	E	G3	yes
Bird	Wood Stork	*Mycteria Americana*	E	G4	-
Bird	Bachman's Warbler	*Vermivora bachmanii*	E	GH	-
Bird	Piping Plover	*Charadrius melodus*	T	G5	-
Mammal	West Indian Manatee	*Trichechus manatus*	E	-	-
Reptile	American Alligator	*Alligator mississippiensis*	T (SA)	-	-

*T = Threatened, E = Endangered, SA = Similarity of appearance.

Red-cockaded Woodpecker (*Picoides borealis*)

Status: Endangered

Red-cockaded Woodpecker (photo by Martjan Lammertink)

Of all plant and animal species known to occur on the FMNF, no other species has a greater influence on Forest Service management than the red-cockaded woodpecker. The FMNF supports the third largest population of the federally endangered red-cockaded woodpecker in the United States, and is one of 13 designated core recovery populations. Prior to Hurricane Hugo in 1989, the red-cockaded woodpecker population exceeded 475 groups and was one of the only known naturally expanding populations. In one night, Hurricane Hugo killed an estimated 63 percent of the red-cockaded woodpecker population, destroyed 87 percent of the cavity trees and 59 percent of the foraging habitat across the Francis Marion National Forest (Hooper et al. 1990, 1991). Approximately 50 percent of the clusters were believed to have lost all of their cavity trees due to the hurricane. In 1990, there were only approximately 205 clusters with at least one active cavity tree present (Hooper 1990). The breeding population had been reduced to approximately 242 potential breeding groups (Figure B-2, Appendix B). By 1995, the population increased to approximately 361 potential breeding groups, which was largely due to the installation of over 1,000 artificial cavities, continued prescribed burning operations, and mechanical habitat improvements (Table 5-2 and Appendix B, Figure B-2). Beginning in 1996, the population began a decline that continued through 1999, culminating in an estimated 314 potential breeding groups. This decline was attributed to lack of suitable cavities and increased midstory vegetation conditions in many areas of the FMNF.

Due to aggressive habitat management and installation of over 2,800 artificial cavities, the red-cockaded woodpecker population has rebounded to approximately 439 active clusters as of January 1, 2013 (Table 5-2 and Appendix B, Figure B-1). The long-term objective in the 1996 Francis Marion Forest Plan is 450 active clusters (page 2-2). At present, we are not far from meeting this objective. In fact, it is highly likely that the FMNF has already exceeded 450 active clusters, but we just have not documented all of the budded clusters that exist on the Forest. Currently, there are a total of 496 managed clusters on the FMNF, of which 426 are potential breeding groups, 13 are single bird groups, and 57 are inactive (Table 5-2 and Appendix B, Figure B-2).

A cluster, as defined in the Recovery Plan, is "the minimum convex polygon containing all of a group's cavity trees and the 61 m (200 ft) buffer surrounding that polygon. The minimum cluster area size is 4.05 ha (10 ac)." Based on this definition, the 496 managed clusters on the FMNF occupy approximately 7,473 acres. The average half-mile foraging partition on the FMNF is approximately 289 acres. The half-mile foraging partitions of all known clusters encompass approximately 143,489 acres. As such, the FMNF currently manages red-cockaded woodpecker habitat on approximately 23,489 more acres than were identified as the habitat management area in the 1996 Forest Plan. Since 2007, the Francis Marion National Forest's red-cockaded woodpecker population has exceeded the recovery goal of 350 potential breeding groups as described in the Recovery Plan for the Red-cockaded Woodpecker (*Picoides borealis*) Second Revision (Red-cockaded Woodpecker Recovery Plan). Despite the fact that the majority clusters on the Forest have foraging habitat that does not meet the recovery standard, the Francis Marion National Forest supports one of the most robust populations in the United States. Based on intensive monitoring conducted during 2009, the average group size on the FMNF is greater than three birds per group, and reproductive success averages approximately 2.3 fledglings per successful nest.

The Francis Marion red-cockaded woodpecker population is expanding in some areas of the Forest, especially in areas that are consistently burned on a 2- to 3-year return interval. Areas that have been consistently burned on a 2- to 3-year return interval are commonly lumped together and referred to as the core burn area (Figure B-3). The FMNF population is truly a testament to the resiliency of the species. Over a third of the red-cockaded woodpecker clusters on the FMNF have foraging at or below the managed stability standard, yet the population continues to grow naturally. Although so many clusters on the FMNF do not meet the recovery standard or managed stability standard, the bird is thriving within the core burn area. There are some areas on the FMNF where clusters are becoming inactive or reduced to single bird groups. These clusters tend to be concentrated in the wildland-urban interface and/or areas where minimal forest management has allowed undesirable midstory succession to occur (Appendix B, Figure B-4). As one might expect, the highest densities of red-cockaded woodpecker clusters are found within the core burn area (Appendix B, Figure B-5).

However, there are some exceptions to this trend. The southwest portion of the Forest, which is commonly referred to as the Wando Area, supports some of the highest densities of red-cockaded woodpecker's and other proposed, threatened, endangered, and sensitive species on the FMNF. In fact, this portion of the Forest likely supports one of the last remaining frosted flatwoods salamander populations in South Carolina, and some of the highest concentrations of Carolina gopher frog breeding wetlands in the state. Unfortunately, the Wando Area has numerous wildland-urban interface issues, which have severely limited the Forest Service's ability to burn this area frequently. Fire and mechanical treatments have been effectively used to greatly improve habitat conditions for species such as the frosted flatwoods salamander and Carolina

gopher frog in some portions of the Wando Area (in compartments 115 and 116). However, some compartments, such as compartment 114 between Highway 41 and Cainhoy Road, have not been burned in over 20 years. In addition to the issues associated with fire exclusion and suppression, there are over 11,000 acres of densely stocked pine and mixed pine hardwood stands in the Wando Area. These dense stands are typically characterized by high fuel loads and suppressed understories. Silvicultural thinning treatments have been used to improve habitat conditions in densely stocked pine stands. Unfortunately, mechanical treatments only provide short-term habitat benefits lasting 2 to 3 years. If thinning is not followed with repeated prescribed burning operations every 2 to 3 years, undesirable midstory conditions quickly deteriorate stand conditions. The accompanying photograph shows a classic example of the pine and hardwood regeneration that can result shortly after a traditional thinning treatment if it is not followed with prescribed burning.

Excessive loblolly pine regeneration 2 years after thinning in compartment 117

In terms of habitat concern, the Wando Area is likely the number one area on the FMNF to be concerned about during the next 10 to 15 years. Virtually all of the proposed, threatened,

endangered, and sensitive species found within the Wando Area are dependent upon fire maintained ecosystems. Due to the fact that it has been so difficult for the Forest Service to adequately burn the Wando Area since the last 1996 Forest Plan Revision, conditions are only expected to deteriorate in the future. This is especially true as urbanization continues to increase along the Highway 41 corridor. Already, large private landholdings along the Highway 41 corridor have been approved for high density housing. Figure B-5 in Appendix B depicts the estimated urban area of Berkeley, Charleston, and Dorchester counties in 2005. Based on The Strom Thurmond Institute's 2005 estimates, the total urban area is expected to increase from 398 square miles in 2005 to 868 square miles in 2030 (Figure B-6). As such the urbanized area of Charleston, Berkeley, and Dorchester counties may more than double in land area between now and 2030.

In terms of forest management designed to benefit the red-cockaded woodpecker and other species of the Longleaf Ecosystem, the FMNF needs to dramatically increase longleaf pine restoration treatments. As of 2013, we estimate the potential range for longleaf on the FMNF at

almost 145,000 acres, including 54,000 acres in Upland Longleaf, and 90,735 acres in Wet Pine Savanna and Flatwoods (55 percent of the Forest). The 1996 Forest Plan estimated the range of Longleaf Pine on the FMNF to be between 37,000 and 75,000 acres. The goal for Longleaf Pine Ecosystem expansion was 21 percent of the Forest. Based on 2013 inventory data, we currently have 49,102 acres (19 percent of the Forest) in the Longleaf and Mixed Longleaf stands. Loblolly pine or loblolly pine/hardwood dominates 104,376 acres on the Forest (40.5 percent), including 25,673 acres (48 percent) of all Upland Longleaf sites and 50,760 acres (56 percent) of Wet Pine Savanna and Flatwoods sites. If the acres in longleaf and loblolly pine are accurate, the percentage of longleaf forest on the FMNF has actually decreased by approximately 35 percent since acquisition in 1936. After the FMNF was acquired in 1936, A.A. Grumbine estimated the dominant forest types (see Table 5-3).

Table 5-3. Acreage and percentage of area by types for stands 1MBM and over per acre, and stands under 1 MBM per acre (acquired and approved)

	Acres by Types and Conditions			
Type	**Stands 1 MBM/A & Above**	**Stands under 1 MBM/A**	**Total**	**Percent**
Longleaf	24,527	51,205	75,738	31
Loblolly	24,813	53,356	78,169	32
Pine Hardwood	12,048	9,036	21,084	9
Bottom Hardwood	9,610	12,335	21,945	9
Hardwood Swamp	4,877	1,865	6,742	3
Pond	13,339	19,937	33,276	13
Bay		4,733	4,733	2
Total Forest	89,214	152,467	241,681	99
Non-Forest		2,151	2,151	1
Total (Acquired and Approved)	89,214	154,618	243,832	100

Note: Loblolly sites range from 50 to 110, with an average site index of 75. Longleaf sites range from 50 to 90, with an average index of 60. Eighty-eight percent of the hardwoods are in sites I and II.

With regards to the red-cockaded woodpecker, prescribed burning is likely the single most important silvicultural treatment utilized on the FMNF. Since 1997, the FMNF has burned approximately 12,995 hectares (32,000 acres) annually, and the Forest will likely burn close to 42,000 acres during 2013. Between 2005 and 2012, 36 percent of our Upland Longleaf and 15 percent or our Wet Pine Savanna and Flatwoods Ecosystems were burned at a desirable frequency (at least 3 or more times on about a 2.6-year burning rotation), and 8 percent of our Upland Longleaf and 11 percent of our Wet Pine Savanna and Flatwoods Ecosystems were burned three times, including at least one growing season burn.

Since Hurricane Hugo, most timber harvesting has consisted of biomass removal and small timber thinning. The FMNF typically masticates approximately 150 acres and selectively thins approximately 1,215 to 1,619 hectares (3,000 to 4,000 acres) annually in order to improve habitat for the red-cockaded woodpecker and other threatened and endangered species. Mastication treatments tend to be concentrated in red-cockaded woodpecker clusters where hardwood midstory is encroaching upon the cativity trees. During 2010, approximately 263 hectares (650 acres) were masticated on the FMNF, which significantly improving red-cockaded woodpecker habitat in numerous red-cockaded woodpecker clusters.

There have been approximately 50,000 acres of stands regenerated on the FMNF since 1989, with over 80 percent of the regeneration occurring between 1989 and 1991 (Figure B-7). Of the 50,000 +/- acres, only 12, 000 to 13,000 acres were restored to longleaf pine (25 percent), while over 31,000 acres (62 percent) of loblolly pine and loblolly pine mixtures were regenerated on the FMNF since 1989 (Figure B-8). As of 2013, these stands are at most 23 years of age, and represent some of the worst ecological conditions found on the FMNF. Most post-Hugo pine stands (loblolly and longleaf) are densely stocked, possess closed canopies, and do not offer good quality foraging habitat for the red-cockaded woodpecker. Based on LIDAR analysis, approximately 33.7 percent of our Longleaf Pine Ecosystems appear to have open canopies (i.e., less than 60 percent canopy cover), 8.5 percent are in savanna condition (i.e., less than 26 percent canopy cover) and 25 percent are in woodland condition (that is, 26 to 60 percent canopy cover). As such, most of our older longleaf stands appear to be in desirable condition. As previously mentioned, many of the longleaf stands that were regenerated after Hurricane Hugo currently offer poor habitat for species such as the red-cockaded woodpecker.

The FMNF only recently began trying to restore longleaf pine in post-Hugo loblolly stands (the 2011 Hellhole Environmental Analysis). The Hellhole Environmental Analysis (Hellhole EA) seeks to restore longleaf on approximately 580 acres of densely stocked loblolly pine stands. Prior to the Hellhole EA, most of these post-Hugo loblolly stands received traditional silvicultural thinnings. These traditional silvicultural thinnings did a wonderful job opening up the canopy and generally improving habitat conditions for species such as the red-cockaded woodpecker, especially within the core burn area. Unfortunately, these treatments have not contributed to longleaf restoration, and instead, many of these traditional thinning treatments have allowed offsite loblolly to persist in many areas that should have been restored to longleaf pine.

As described earlier, thinning is only a short-term habitat enhancement for the red-cockaded woodpecker if it is not properly maintained with prescribed burning. In terms of red-cockaded woodpecker habitat, the benefits from thinning typically only last 2 to 3 years on the FMNF if the thinnings are not maintained with an adequate fire return interval (personal observations). Mechanical tree thinnings tend to be costly, especially if the material is unmerchantable. In many cases, the Forest Service has had to rely on costly mastication treatments to restore and maintain red-cockaded woodpecker habitat, especially in the wildland-urban interface. These mastication treatments have cost the Forest Service anywhere from $200 to $600 per acre, while traditional pre-commercial thinning (also known as biomass thinning) has cost the Forest Service upwards of $150 per acre.

Fire can be used as a means to thin over stocked pine stands at a fraction of the cost (economic and/or ecologic) of traditional mechanical silvicultural methods (Wade 1993). The results of Wade 1993 indicate that low-intensity (<346 KWIm) backing fires can produce a thinning from below where groundline diameter range in overstocked loblolly pine stands is wide enough to allow differential survival and where the trees targeted for removal have groundline diameters less than 3.8 centimeters (1.50 inches). Thinning by fire occurs regularly inside the core burn area, and has been extremely useful in opening up closed canopy pine stands. Unfortunately, most of the prescribed burning on the FMNF takes place during the dormant season between February and April. Burning during this time period rarely gets hot enough to thin longleaf pine, especially as they increase in height and diameter. As a result, exceptionally dense longleaf understory and midstory is developing across certain areas of the FMNF, especially in longleaf pine stands along the Halfway Creek Road corridor stretching from the Southampton Road/Halfway Creek Road intersection to the Halfway Creek Road/Highway 45 intersection.

Red-cockaded woodpecker being translocated to Okefenokee National Wildlife Refuge

The Honey Hill Environmental Analysis (Honey Hill EA), completed in 2009, was actually the first large longleaf restoration proposed on the FMNF since the early 1990s. The Honey Hill EA seeks to restore longleaf pine across approximately 780 acres, which are concentrated east of Highway 45. Longleaf restoration treatments such as those proposed in the Honey Hill and Hellhole EAs should prove beneficial for numerous species that are dependent upon the Longleaf Pine Ecosystem. The FMNF should focus all future silvicultural activities on restoration and enhancement of natural ecological systems, especially with regards to the Longleaf Pine Ecosystem. By focusing efforts on restoration and enhancement, native species dependent upon specific ecological systems and conditions will benefit, including species such as the red-cockaded woodpecker.

Beginning in 2008, the FMNF facilitated a translocation and monitoring project which lasted until 2010. This project was conducted in cooperation with the University of Georgia, Southeast Regional Partnership for Planning and Sustainability (SERPPAS), USDA Forest Service, and the Southern Range Translocation Cooperative (SRTC). SERPPAS funded a fulltime red-cockaded woodpecker biologist, whose sole responsibility was to ensure success of the translocation project on the FMNF. In association with this project, approximately 102 red-cockaded woodpecker clusters were monitored each year from 2008 to 2010, and nestlings were banded in approximately 94 clusters annually. Following a severe winter in 2009/2010, the 2010 translocation clusters had slightly smaller group and brood sizes, with a higher percentage of females fledging than in previous years (i.e., 57 versus 52% in 2009). During 2009, only one of the translocation clusters did not have at least one helper. However, in 2010 at least seven clusters did not have a helper. Several groups initiated nests earlier than in previous seasons with the earliest banding dates being 3 to 4 days earlier than in the past years. Also, the peak banding dates were not as clearly defined as in previous breeding seasons with the daily number of nests scheduled to band being spaced more evenly throughout May rather than most banding taking place the third week of May. A total of 186 red-cockaded woodpecker nestlings were banded in 101 nesting attempts from 102 groups that were monitored during 2010. For the 102 groups monitored, an average group size of 3.27 (N=50) was estimated. Within these 102 red-cockaded woodpecker groups, 7 initial nest attempts failed, 9 groups did not attempt a nest and 5 groups had clutches that did not hatch. The nestlings of three re-nests were successfully banded while four groups had nests that failed during the second attempt. Of all nestlings, 184 reached 21 days old and these were assumed to have fledged. For groups that fledged young, an average of 2.1 nestlings fledged/nest (n=88). For fledglings that were able to be sexed, 57.1 percent were females (n=101) and 42.9 percent (n=76) were males). During pre-fledge nest checks, 32 nests had either a lone nestling of known sex or all nestlings were the same sex. These clusters were not re-visited for post-fledge checks during 2010. The remaining clusters were re-visited post-fledge to assign a sex to the band combination of the banded birds.

Buccal swab sample being obtained from sub-adult red-cockaded woodpecker

Based on allocations determined at the 2010 SRTC meeting, six pairs of sub-adults were translocated to U.S. Army Garrison Fort Jackson (Richland County, South Carolina) on 6 and 21 October, 2010, two pairs were translocated to Savannah River Site on 21 October, 2010, and two pairs went to the U.S. Air Force's Poinsett Electronic Combat Range (Sumter County, SC) on 1 November 2010. This translocation project has not only saved the government money in terms of red-cockaded woodpecker monitoring, but has also identified 20 to 30 new budded and pioneered clusters. These budded clusters would not have been found during our typical annual monitoring activities.

The FMNF translocated 49 red-cockaded woodpeckers between 2008 and 2009. During the 2009 translocation project, four pairs of sub-adults were translocated to Ocala National Forest, five pairs went to the Talladega National Forest and five pairs went to Joseph E. Jones Ecological Research Center at Ichauway. During 2008, a total of 245 nestlings were banded for an average number of chicks per banded nest of 2.4 (compared to 1.8 on the Osceola National Forest), reflecting the size and "maturity" of the FMNF versus the Osceola National Forest. During 2008 post-fledge checks, the red-cockaded woodpecker biologist found and sexed 229 fledglings. Sixteen of the 245 nestlings were not found, and presumed dead as a result of nest failure. Based on allocations determined at the 2008 Southern Range Translocation Cooperative (SRTC) meeting, four pairs of sub-adults were translocated to U.S. Army Garrison Fort Jackson, three pairs went to the Okefenokee National Wildlife Refuge, and three pairs were translocated to Military Ocean Terminal Sunny Point in North Carolina. Of the 20 birds translocated in 2008, 60 percent were successful, which exceeded the regional (SRTC) 2008 success rate of 53 percent (McDearman 2011). In 2009, the FMNF birds experienced a lower-than-average success rate of 46 percent; the STRC average success rate for 2009 was 51 percent (McDearman 2011). Yearly variation is normal and both years were within reasonable range of the SRTC overall average.

Additional data that was gleamed from the translocation project pertained to genetics. Based on buccal swabs obtained from the FMNF and three small recipient red-cockaded woodpecker populations (i.e., Joseph W. Jones Ecological Research Center at Ichauway, Silver Lake Wildlife Management Area and Enon/Sehoy Plantations) , Alstad 2010 was able to analyze genetic diversity of these populations based on multi-locus microsatellite genotypes and mitochondrial haplotypes in an AMOVA framework. On the FMNF, one nestling was randomly chosen and swabbed per nest from 55 randomly selected nests, during April and May of 2008 and 2009 (Alstad 2010). Researchers were also able to obtain buccal swabs from 20 sub-adults being translocated from Francis Marion to recipient populations. The results of Alstad 2010 suggested that range-wide translocations can mitigate some of the detrimental effects associated with population fragmentation. However, his results also showed that there are still sufficient reasons to be concerned about the genetic health of small isolated red-cockaded woodpecker populations (Alstad 2010). A low rate of gene flow due to significant geographic isolation, lack of translocations, and subsequent random drift may have affected linkage disequilibrium in the

Francis Marion red-cockaded woodpecker population (Alstad 2010). Due to the shear destruction of Hurricane Hugo, the Francis Marion red-cockaded woodpecker population likely experienced a genetic bottleneck when Hurricane Hugo struck in 1989 (Alstad 2010). Alstad 2010 detected significant inbreeding (FIS) in all of the red-cockaded woodpecker populations that were examined. The FMNF had a moderate level of inbreeding (FIS = 0.29 for one individual per cluster sampled). While this could be an artifact of the Hurricane Hugo bottleneck, other mechanisms may also influence measures of inbreeding in this population (Alstad 2010). Compared to most other red-cockaded woodpecker populations, the FMNF still exhibits a high degree of genetic diversity, especially when considering what the FMNF population went through after Hurricane Hugo.

Although systematic surveying of suitable habitat is not possible at this time, pioneer clusters are regularly located by Forest Service employees during the course of their normal field activities, as well as with annual monitoring activities. Beginning in 2006, the FMNF monitored at least 33 percent of the red-cockaded woodpecker population annually so that the entire population was monitored after 3 years. However, due to funding constraints, no monitoring was conducted during 2011, and the Forest began monitoring 20 percent of the population during 2012. The 20 percent annual sample was randomly selected using Hawth Tools in ArcGIS, so that the entire population will be monitored after 5 years. The population growth rate has somewhat slowed since 2010, but growth is expected to continue as habitat enhancement/maintenance practices are consistently implemented. Artificial recruitment clusters have been routinely installed on the FMNF where possible. However, one of the biggest obstacles to establishing new recruitment clusters is locating large enough cavity trees within suitable habitat. Where there is suitable habitat, cluster density is so high that it is virtually impossible to find suitable locations for recruitment clusters. As such, the FMNF has not established any new recruitment clusters since 2008. The population is naturally expanding on its own. As such, our focus since 2006 has been to provide each cluster with at least 4 suitable cavities, and to provision clusters with replacement inserts and restrictor plates as needed.

Hurricanes will always be a potential threat to the red-cockaded woodpecker on the FMNF. Since 1700, there appear to have been about 18 hurricanes that probably affected the FMNF (Langley and Marter 1973; Calhoun 1983; USACE 1986; Neumann et al. 1987; Hooper 1990). These data suggest the FMNF is subjected to hurricane-force winds about once every 16 years. This estimate may be inflated because it is impossible to get specific information about the early hurricanes. However, the mean elapsed time between hurricanes is fairly stable across centuries (1700s, 16.7; 1800s, 14.3; and the 1900s, 17.8). Clearly, not all these hurricanes had the same effect as Hugo, but cavity trees are at risk relatively frequently. Knowledge and experience gained from managing the catastrophic damage of Hurricane Hugo has well equipped the FMNF in the areas of hurricane preparedness and response.

Hooper 1990s discussion related to red-cockaded woodpecker's and hurricanes is the most logical, yet most impractical too: "The best biological answer is appealing but impractical: revert back to pre-Columbian conditions. In that era, hurricanes no doubt destroyed large areas of red-cockaded woodpecker habitat and killed large numbers of the birds but had relatively little impact on the species as a whole. Now with the bird existing in habitat islands, hurricanes are a menace to the species. The next best answer is to have as many geographically large populations as possible. An extensive population is desirable because a single hurricane is less likely to destroy the entire population beyond the point that it can recover. Cooperative management agreements with owners of private land adjacent to public land with red-cockaded woodpeckers may be the most practical way to increase the geographic extent of a population."

Although the red-cockaded woodpecker population has rebounded to historically high numbers, the Francis Marion National Forest will have to continue aggressive habitat management and monitoring for many years to come. As long as there are no catastrophic events, it is anticipated that the artificial cavity program will continue to be needed until there are vast amounts cavity-size pines in suitable habitat for the red-cockaded woodpecker. This may take as long as 40 years due to Hurricane Hugo's destruction. The artificial cavity program typically consists of installing approximately 150 structures per year. These structures mainly consist of replacement inserts and restrictor plates. However, new inserts, drilled cavities, and drilled starts are installed each year, especially in clusters with less than five to six suitable cavities. Monitoring 20 percent of the red-cockaded woodpecker population each year so that the entire population has been monitored after 5 years is significantly less than what the FMNF historically monitored. However, this level of monitoring is sufficient to gauge the health and viability of the red-cockaded woodpecker population.

Two- year old* A. cingulatum *collected as a larva on FMNF in 2010

Due to the uncertainties that exist with the red-cockaded woodpecker population on the Francis Marion National Forest, and trends that have occurred when suboptimal conditions existed in past years, monitoring will continue to be needed for many years to come. Ideally, the FMNF will continue to serve as a source for future translocation projects. Due to its size and health, the Francis Marion red-cockaded woodpecker population will be critical for augmenting existing small populations, as well as efforts to reintroduce the species into new habitats. Future translocation projects will not only benefit the species throughout its range, but will also allow us to gleam detailed population information such as that generated from the 2008 to 2010 translocation projects.

Frosted Flatwoods Salamander (*Ambystoma cingulatum*)

Status: Federally threatened

The frosted flatwoods salamander is a federally threatened mole salamander which breeds within seasonally flooded isolated wetlands within fire-maintained pine woodlands and savannas. This salamander burrows near water or moves about under debris on the forest floor. It is carnivorous and an opportunistic feeder, primarily eating earthworms and arthropods. The species needs shallow winter ponds to breed, and does not do well in ponds that contain fish. The timing and frequency of rainfall is critical to the successful reproduction and recruitment of flatwoods salamander (Final Rule for Listing, 1999).

A. cingulatum *larva collected on the FMNF during March 2010*

Surviving populations are currently threatened by habitat loss and degradation from agriculture, urbanization, and various silvicultural practices (Final Rule for Listing, 1999). The flatwoods salamander is extremely rare in South Carolina, and the FMNF is home to one of only four known populations in the entire state. Most known, historic and potential frosted flatwoods salamander breeding wetlands on the Forest (as identified by Harrison in monitoring report dated 2004) occur within the Wando Area of the FMNF. Conservation measures for the species are included in the final rule for listing (*Federal Register* Vol.64, No.62:15703), and address management activities within a 450-meter radius of known flatwoods salamander breeding ponds. Only 8 adults and approximately 12 larvae have been captured on the Francis Marion in the past 20 years (Harrison 2004, 2005; Palis 2009, internal USFS records). Initial observations of flatwoods salamanders on the Francis Marion National Forest were made by Julian Harrison in the early 1950s through 1970 (Harrison 2003). Subsequent observations were made during flatwoods salamander surveys by Moulis and Seyle (1987) and Moulis and Williamson (1998). More recent observations of flatwoods salamanders on FMNF were made fortuitously. John Fauth captured four adults in October 1995 and a single larva in 2003 (Harrison 2003), William Resetarits encountered an adult on Hoover Road in June 1997 (internal Forest Service documentation), and a single adult was captured in Hoover Pond in 2002 (Harrison 2003). Unsuccessful surveys for flatwoods salamanders on FMNF were conducted in 1991 (by USDA Forest Service employees), 1995 (Bennett 1995), 2000 (Humphries 2000), 2001 (Harrison 2001; Waldron 2001), 2003 (Harrison 2003), 2009 (Palis 2009), and 2010 (Palis and Klaus).

The majority of sampling on the Forest is conducted via dip-netting and deployment of minnow traps for larval salamanders. Since 2006, the FMNF has only been able to conduct surveys for this species during 2009 and 2010 due to drought conditions. During 2010, John Palis and Joyce Marie Klaus conducted surveys on the FMNF. Nineteen wetlands were surveyed, and *Ambystoma cingulatum* was documented on the Forest for the first time since 2003. Six larvae were collected from a previously undocumented breeding wetland during March 2010. Three larvae were taken to Riverbanks Zoo in Columbia, South Carolina, where Scott Pfaff (Curator of Herpetology) successfully raised them to metamorphosis. At the time of collection, the larvae were too small to collect tail tissue, so the zoo reared them until they were big enough to collect tissue. DNA analysis was performed, and results indicate that individuals from the FMNF do not represent a distinct species, and are closely related to other populations of the frosted flatwoods salamander. This was the first genetic material available from South Carolina.

The August 13, 2008, *Federal Register* (Volume 73, Number 157) designated critical habitat for *A. cingulatum*. Critical habitat on the Francis Marion was given the unique identifier of Unit FFS-6. The *Federal Register* stated the following for Unit FFS-6:

> Unit FFS-6 occupied at the time of listing, encompasses 1,300 ac (526 ha) on Federal and private land in Berkeley County, South Carolina. This unit is bisected by State Highway 41 approximately 10 mi (16 km) south of the town of Huger. Within this unit, 1,176 ac (476 ha) are in the Francis Marion National Forest and 124 ac (50 ha) are on private land. Land within this subunit owned by the U.S. Forest Service is protected from agricultural and urban development; however, threats remain to frosted flatwoods salamander habitat that may require special management of the PCEs. These threats include the potential for fire suppression, potential detrimental alterations in forestry practices that could destroy the below-ground soil structure, and potential hydrologic changes resulting from adjacent highways and roads that could alter the ecological functioning of the breeding pond and surrounding terrestrial habitat. Special management of the PCEs may also be required for the threats posed by agricultural and urban

> development on the lands in private ownership. All lands proposed for designation contain all PCEs and support multiple frosted flatwoods salamander life processes."

In terms of the species' natural history requirements, the August 13, 2008, *Federal Register* provides the following useful information:

> Food, Water, Air, Light, or Other Nutritional or Physiological Requirements
>
> Post-larval frosted and reticulated flatwoods salamanders eat small invertebrates that share their fossorial habit. Records exist of earthworms that have been found in the stomachs of dissected adult salamanders (Goin 1950, p. 314). Larval flatwoods salamanders most likely prey on a variety of aquatic invertebrates and perhaps small vertebrates such as other amphibian larvae (Palis and Means 2005, p. 608). Data from a recent study of larval food habits found that freshwater crustaceans dominated stomach contents of preserved, wild-caught individuals from Florida and South Carolina (Whiles et al. 2004, p. 208). This indicates a preference for freshwater crustaceans or perhaps is an indication that these invertebrates are the most abundant or most easily captured prey in breeding ponds.
>
> Within the pine uplands, a diverse and abundant herbaceous layer consisting of native species is important to maintain the prey base for adult frosted and reticulated flatwoods salamanders. Wetland water quality is important to maintain the aquatic invertebrate fauna eaten by larval salamanders. An unpolluted wetland with water free of predaceous fish, sediment, pesticides, and the chemicals associated with road runoff, is important to maintain the aquatic invertebrate fauna eaten by larval salamanders.
>
> Cover or Shelter
>
> At wetland sites, developing larval frosted and reticulated flatwoods salamanders hide in submerged herbaceous vegetation during the day (Palis and Means 2005, p. 608) as protection from predators. Thus, an abundant herbaceous community in these ponds is important for cover. Generally, flatwoods salamander breeding pond and upland habitats are separated by an ecotone (area of transitional habitat) through which salamanders must move during pre- and post-breeding events (Palis 1997, p. 58). The graminaceous (grass-like) ecotone represents a distinct habitat type and is important for maintaining connectivity between aquatic and terrestrial habitats. When the ecotone provides cover and appropriate microclimatic conditions, survival of migratory salamanders is enhanced. Studies of migratory success in post-metamorphic salamanders have demonstrated the importance of high levels of survival of these individuals to population maintenance and persistence (Rothermel 2004, pp. 1544-1545). Post-larval and adult frosted and reticulated flatwoods salamanders occupy upland flatwoods sites where they live underground in crayfish burrows, root channels, or burrows of their own making (Goin 1950, p. 311; Neill 1951, p. 765; Mount 1975, pp. 98-99; Ashton and Ashton 2005, pp. 63, 65, 68-71). The occurrence of these belowground habitats is dependent upon protection of the soil structure within flatwoods salamander terrestrial sites.

As published in *Federal Register* Volume 74 Number 26, the USFWS finalized the listing under the Endangered Species Act of 1973 of the currently threatened flatwoods salamander (*Ambystoma cingulatum*) into two distinct species: frosted flatwoods salamander (*Ambystoma cingulatum*) and reticulated flatwoods salamander (*Ambystoma bishopi*). The USFWS made a determination of endangered status for the reticulated flatwoods salamander, and retained threatened status for the frosted flatwoods salamander (*Federal Register* 2009). Designated

critical habitat for the frosted flatwoods salamander and the reticulated flatwoods salamander were further finalized in *Federal Register* Volume 74 Number 26.

Due to its potential for maintaining and increasing the number of metapopulations, the Francis Marion National Forest is likely the most important habitat for the frosted flatwoods salamander

Loblolly pine regeneration approximately 2 years after thinning

in all of South Carolina. As with numerous other endangered and threatened species, public lands are critical for ensuring species viability. Twenty-two (88 percent) of the known frosted flatwoods salamander populations occur primarily on public land (*Federal Register* 2009). Sixteen of the populations (64 percent of total populations of the species) on public land represent metapopulations supported by more than one breeding site (*Federal Register* 2009). Unfortunately, all known current and historic frosted flatwoods salamander breeding wetlands are found in the Wando Area of the FMNF. As previously mentioned in this document, the Wando Area is one of the most rapidly urbanizing areas on the Francis Marion National Forest, and supports some of the highest densities of proposed, endangered, threatened, and previously identified Forest sensitive species on the Forest. In terms of habitat concern, the Wando Area is likely the number one area on the FMNF to be concerned about during the next 10 to 15 years. Virtually all of the proposed, threatened, endangered, and sensitive species found within the Wando Area are dependent upon fire maintained ecosystems. Due to the fact that it has been so difficult for the Forest Service to adequately burn the Wando Area since the last 1996 Forest Plan Revision, conditions are only expected to deteriorate in the future if adequate fire return intervals are not maintained in this area.

Fire and mechanical treatments have been effectively used to greatly improve habitat conditions for species such as the frosted flatwoods salamander and Carolina gopher frog in some portions of the Wando Area (i.e., compartments 115 and 116). However, some compartments, such as compartments 113 and 114 between Highway 41 and Cainhoy Road, have not been burned in over 20 years. When fire is suppressed and excluded from fire dependent ecosystems, undesirable habitat conditions and rates of forest succession occur. In addition to the issues associated with fire exclusion and suppression, there are over 11,000 acres of densely stocked pine and mixed pine hardwood stands in the Wando Area. These dense stands are typically

characterized by high fuel loads and suppressed understories, and offer marginal habitat for species such as the frosted flatwoods salamander. Silvicultural thinning treatments have been used to improve habitat conditions in densely stocked pine stands all across the FMNF. Unfortunately, mechanical treatments only provide short-term habitat benefits lasting 2 to 3 years, especially if the residual basal areas are fairly high (e.g. residual basal area of pine > 50 ft^2/ac). If thinning is not followed with repeated prescribed burning operations every 2 to 3 years, undesirable midstory conditions quickly deteriorate stand conditions. Numerous thinned loblolly pine stands along Halfway Creed Road in compartments 115, 116 and 117 provide credence to this assertion, as the habitat benefits from the thinning only lasted 2 to 3 years due to the lack of prescribed burning. The hardwood and loblolly pine midstory is exceptionally dense in these recently thinned pine stands, and is upwards of 6 to 8 feet tall in places. From a biological and ecological standpoint, it would have likely been more beneficial to remove all of the loblolly pine in these young stands than to only thin them. The following picture is another picture taken in compartment 117 during 2012, and depicts the undesirable loblolly regeneration that resulted 2 years after thinning without prescribed fire. If an adequate fire return interval is not maintained in a stand such as this, habitat conditions will continue to deteriorate, and it will be virtually useless to a species such as the frosted flatwoods salamander, red-cockaded woodpecker and Carolina gopher frog.

Numerous isolated wetlands have been severely altered by previous land management practices on the FMNF. Some of the best examples of frosted flatwoods salamander breeding wetlands on the FMNF are bordered by the Tuxbury Horse Trail in compartments 114, 115, and 116. Much of the Tuxbury Trail runs along a former tram bed that was used to transport lumber in the early to mid-1900s. This tram bed is impacting numerous isolated wetlands in the Wando Area, including potential frosted flatwoods salamander and Carolina gopher frog breeding wetlands. This tram is impacting the hydrology of numerous isolated wetlands due to the fact that it is ditched on both sides and was intentionally built up to traverse through wetlands.

Unfortunately, there are no culverts or bridges on this horse trail/tram. As such, this artificial land feature serves as a barrier to sheet flow and is impacting the hydrology of adjacent wetlands. Additionally, the ditches on either side of the tram drain adjacent wetlands and serve as vectors for undesirable aquatic organisms such as fish. Restorative activities need to be implemented in areas such as compartments 114, 115, and 116 to improve habitat conditions for the frosted flatwoods salamander and other isolated wetland dependent organisms. Due to the potential threats that exist in the Wando Area, the FMNF needs to examine opportunities for translocation and reintroduction of species such as the frosted flatwoods salamander and Carolina gopher frog in the future. Because all known *A. cingulatum* breeding wetlands on the FMNF only occur in the Wando Area, it is conceivable that this species could become extirpated on the FMNF if habitat conditions continue to degrade in this area. As indicated throughout this portion of the assessment, the habitat conditions with the Wando Area have, and are expected to continue to degrade if appropriate land management practices are not implemented (such as, adequate fire frequency).

Translocation and reintroduction of *A. cingulatum* to other suitable habitats on the FMNF would increase the number of metapopulations on the FMNF, and could offset the potential impacts of continued habitat deterioration in the Wando Area. There are numerous habitats within the core burn area that could support the frosted flatwoods salamander and Carolina gopher frog. It is highly likely that the frosted flatwoods salamander and Carolina gopher frog once occurred across the entire FMNF, especially along the Cainhoy Ridge and Bethera Ridge. However, due

to their highly specialized habitat requirements and environmental sensitivity, past destructive land practices likely lead to the demise of virtually all metapopulations on the FMNF.

L. capito ***captured in April 2009***

Carolina Gopher Frog (*Lithobates capito capito*)

Status: State endangered, petitioned for Federal listing and positive 90-day finding

The Carolina gopher frog is a member of the family Lithobatidae, the true frogs. Its closest relatives include the bullfrog, leopard frog, and bronze frog. This species can reach sizes of 6 to 9 centimeters (2.4 to 3.5 inches). It has the body shape of a typical frog, but is a little plumper than other frogs with proportionately shorter legs. Gopher frogs are typically light to dark brown with heavy blotching and numerous warts (Conant and Collins 1991; Martof et al. 1980). In fact, while it is a true frog, the Carolina gopher frog does somewhat resemble a toad in appearance, due to the presence of the warts. This trait, as with the toad, is evidence of a more terrestrial lifestyle. Similar to the frosted flatwoods salamander, the Carolina gopher frog spends the majority of its adult life cycle in terrestrial habitats as fossorial species, inhabiting crayfish holes, root channels, stump holes, rodent burrows, and other subterranean cavities. Although the frosted flatwoods salamander typically migrates to its breeding wetlands during autumn and early winter rains (Anderson and Williamson 1976), the Carolina gopher frog migrates to its breeding wetlands in late winter and early spring (Braswell 1993). However, under the right environmental conditions, the Carolina gopher frog may breed throughout all of the spring months. The Carolina gopher frog was documented from several breeding wetlands on the FMNF and adjacent properties on 23 February, and 30 April, 2013. The aquatic larva of these species may spend several months in a breeding wetland before metamorphosis occurs. Newly metamorphosed individuals move away from breeding wetlands into the surrounding uplands, and only return to these wetlands when they become reproductively mature adults (Petranka 1998).

Prescribed fire is critically important for proper Carolina gopher frog habitat maintenance and enhancement. This includes both their non-breeding terrestrial habitat as well as their breeding wetlands. Fire should never be prevented from burning up to and within Carolina gopher frog breeding wetlands on the FMNF. Unfortunately, this was not always the case on the Francis Marion, and firebreaks were actually constructed around some wetland habitats in order to prevent fire from entering into them.

Evidence of these firebreaks can still be found on the FMNF today, but luckily, this destructive practice is no longer used. Gopher frogs appear to have an affinity for fire maintained habitats. In a radio telemetry study conducted on the Ocala National Forest in Florida, researchers reported that dispersing juveniles actually selected fire-maintained habitat that was associated with an open canopy, few hardwood trees, small amounts of leaf litter, and large amounts of wiregrass (Roznik and Johnson 2009). Timing of prescribed fire may be critical for minimizing direct mortality of individuals. Timing prescribed fire to occur when individuals are less likely to

be moving during a breeding period or post-metamorphosis migration will minimize effects to the species. The FMNF has never identified formal guidance on the timing of prescribed burning for *A. cingulatum* or *L. capito*. Guidance on the timing of prescribed burns where these two species are known to occur should be a priority. The following burn matrix was developed on the DeSoto National Forest, where the Mississippi gopher frog (*Lithobates sevosa*) is known to occur. This burn matrix could prove useful on the FMNF as well.

The Carolina gopher frog has been documented from 13 isolated wetlands on the FMNF since 1997 (internal Forest Service records). Since 2006, it has been observed acoustically or visually from eight isolated wetlands on the FMNF, including a previously undocumented breeding wetland along Halfway Creek Road that was discovered during 2013.

Table 5-4. Example burn matrix from Desoto National Forest, which could be modified for use within *A. cingulatum* and *L. capito* habitat on the FMNF

Forest Service Burn Conditions**	Burn Uplands	Burn Pond Basin
Use existing standards		
Frog Parameters		
Adult frogs not in pond (January–March)	Yes	No
Adult frogs in pond	No	No
Adult frogs not in pond (April–September)	Yes	Yes
Burning (October–December)	No	No
Most (> 75%) adult frogs left pond (>7 days since last movement at drift fence)	Yes	No
Tadpoles present and after April 1	No	No

One of the largest Carolina gopher frog (*Lithobates capito*) breeding events in the past 10 years was documented on the FMNF during April 2009. Hundreds of individuals were documented in known breeding wetlands. Dipnetting for larval Carolina gopher frogs was conducted by USDA Forest Service and Department of Natural Resources personnel on June 2, 2009. Carolina gopher frog tadpoles and questionable tadpoles were collected and sent to the Riverbanks Zoo in Columbia, South Carolina. These tadpoles were successively raised at the Riverbanks Zoo, and the zoo now has three subadult Carolina gopher frogs. The frogs will be kept in captivity at the zoo in order to study the species' feeding habits and lifespan. Genetic material will be collected and analyzed for comparison with other *Lithobates capito* populations. Breeding was also confirmed on the FMNF during 2010 and 2013.

2009 pig damage to* A. cingulatum *breeding wetland

Beginning in 2007, Mark Danaher installed three North American Amphibian Monitoring Program (NAAMP) frog routes on the FMNF. These NAAMP routes are run three times per year and are designed to monitor anuran populations. The primary goal of these frog routes is to assess frog and toad population trends using a calling survey technique. Overall, frog and toad trends on the FMNF appear to be stable, but long-term monitoring is needed to account for temporal variation and the complex life histories of our native amphibians. Species such as the Carolina gopher frog and frosted flatwoods salamander are in a critical state, and are highly susceptible to local extirpation without proper protection and habitat management. These NAAMP routes provide the Forest Service with an efficient means of documented and monitoring trends of anurans. Had it not been for one of the NAAMP routes, a newly discovered Carolina gopher frog breeding wetland would not have been found in 2013. The FMNF and other protected lands in South Carolina provide critical refuges for isolated wetlands, which are critical habitats for species such as *L. capito capito* and *A. cingulatum*. These palustrine wetlands are critical for ensuring

the continued viability of pond breeding amphibians, especially rare and declining species such as *L. capito*, *A. cingulatum* and the dwarf siren (*Pseudobranchus striatus*). Some of the highest densities of isolated wetlands on the FMNF occur along the Cainhoy Ridge and Bethera Ridge formation, and are primarily depressional-type wetlands. As such, these geologic formations also offer some of the best opportunities to increase metapopulations of species such as the Carolina gopher frog.

Many isolated wetlands on the FMNF have and continue to be impacted by roads, ditches, past silvicultural practices, utility right-of-ways, former tram beds, illegal vehicular activities, and non-native invasive species such as the wild pig (*Sus scrofa*). In some instances, the lack of appropriate management practices (i.e., fire suppression and exclusion) has significantly degraded known breeding wetlands for the Carolina gopher frog and frosted flatwoods salamander. Research by Burke and Gibbons (1995) and Semlitsch (1997) have indicated that terrestrial buffers should be left around wetlands to protect the semi-aquatic organisms that utilize them, although no scientific study has explicitly shown that forested buffers are a necessity for isolated wetland herpetofaunal viability (Russell et al. 2002b). The FMNF has never required terrestrial buffers around isolated wetlands during logging activities unless there were isolated wetland dependent proposed, threatened, endangered, and sensitive species within the project area. Personal communication with Julian Harrison, an expert on FMNF herpetofauna, indicated that one of the biggest changes to *A. cingulatum* and *L. capito* breeding wetlands on the FMNF was hardwood shrub and tree encroachment, both within the wetland ecotones and the wetlands themselves. Changes in vegetation like this can significantly degrade breeding wetlands for species such as *A. cingulatum* and *L. capito*. Both of these species require open herbaceous dominated wetlands and adjacent uplands for their survival.

Roads can have significant adverse ecological and biological effects on amphibians and reptiles, as well as numerous other faunal groups. Some heavily traveled paved roads on the FMNF cause significant amphibian and reptile mortality (for instance, Highway 17, Highway 41, Highway 402, Highway 45, and Steed Creek Road). As the human population continues to increase in the counties of Berkeley, Charleston, and Dorchester, wildlife road mortality is expected to continue to increase as more vehicles are on the roads. Road impacts on wildlife need to be assessed on the FMNF in order to identify potential mitigation measures. Roads contribute to habitat fragmentation by isolating blocks of remaining contiguous habitat. They may disrupt migration routes and dispersal of individuals to and from breeding sites. Roads and road construction can negatively impact hydrology of wetlands and destruction of breeding ponds. In addition, vehicles may also cause the death of amphibians when they are attempting to cross roads (Means 1996). Road construction resulted in the destruction of a historic reticulated flatwoods salamander breeding pond in Escambia County, Florida (Palis 1997b). Rare species such as the Carolina gopher frog have been killed by vehicle traffic on Highway 41 in the Wando Area. The Francis Marion has no mitigation measures in place on the Forest to mitigate the negative impacts of roads on wildlife (such as, travel corridors).

Rana viruses in the family Iridoviridae and the amphibian chytrid fungus (*Batrachochytrium dendrobatidis*) may be other potential threats to amphibians on the FMNF, although the susceptibility of the *A. cingulatum* and *L. capito* to these diseases is unknown. Rana viruses have been responsible for mass die-offs of tiger salamanders throughout western North America and spotted salamanders (*A. maculatum*) in Maine (Daszak et al. 1999; USFWS 2009). Chytrid fungus has been discovered and associated with mass mortality in tiger salamanders in southern Arizona and California, and the Santa Cruz long-toed salamander (*A. macrodactylum croceum*) (Vredenburg and Summers 2001; Davidson et al. 2003; Padgett-Flohr and Longcore 2005;

USFWS 2009). There are just too many unknowns associated with the introduction of rana viruses. Had there been proactive mitigation measures in place prior to the mass die-offs of bats from white-nose syndrome, some colonies might have been saved. There have been no documented occurrences of rana viruses or chytrid fungus on the FMNF to date, but these viruses and fungus are a huge concern should they ever be introduced. Precautionary measures should be taken to minimize the chances of introducing these lethal viruses and fungus.

5.3.3 Potential Species of Conservation Concern

In addition to federally listed species, additional lists of species of conservation concern compiled from the 1996 Francis Marion Plan, State Comprehensive Wildlife Management Strategy, partner input, and USFWS 2012 Berkeley and Charleston county lists of rare species appears in **Error! Reference source not found.**.

Table 5-5. Potential terrestrial animal species of conservation concern

Taxa	Common Name	Scientific Name	Global Rank	State Rank
Bird	*Accipiter cooperii*	Coopers hawk	G5	S3
Bird	*Acris crepitans*	Northern cricket frog	G5	S5
Bird	*Aimophila aestivalis*	Bachman's sparrow	G3	S3
Invertebrate	*Amblyscirtes alternata*	Dusky roadside skipper	G2, G3	
Amphibian	*Ambystoma cingulatum*	Eastern tiger salamander	G5	S2,S3
Bird	*Ammodramus maritimus*	MacGillivray's seaside sparrow	G4	
Bird	*Anas rubripes*	American black duck	G5	
Bird	*Charadrius wilsonia*	Wison's plover	G5	S3
Reptile	*Clemmys guttata*	Spotted turtle	G5	S5
Bird	*Colinus virginianus*	Northern bobwhite	G5	
Reptile	*Corynorhinus rafinesquii*	Rafinesque's big-eared bat	G3,G4	S2
Mammal	*Condylura cristata*	Star-nosed mole	G5	S3
Reptile	*Crotalus adamanteus*	Eastern diamondback	G4	S3
Bird	*Dendroica discolor*	Prairie warbler	G5	
Bird	*Dendroica virens* (Wayne's)	Black-throated green warbler	G5	S4
Amphibian	*Desmognathus auriculatus*	Southern dusky salamander	G5	
Bird	*Elanoides forficatus*	American swallow-tailed kite	G5	S2
Bird	*Haleiaeetus leucucephalus*	Bald eagle	G5	S2
Reptile	*Heterodon simus*	Southern hognose snake	G2	
Bird	*Hylocichla mustelina*	Wood thrush	G5	S3
Bird	*Ictinia mississippiensis*	Mississippi kite	G5	S4
Bird	*Lanius ludovicianus*	Loggerhead shrike (migrant)	G4	S3
Mammal	*Lasiurus cinereus*	Hoary bat	G5	
Bird	*Laterallus jamaicensis*	Black rail		
Bird	*Limnothlypis swainsonni*	Swainson's warbler	G4	S4
Amphibian	*Lithobates capito*	Gopher frog	G3	S1
Bird	*Melanerpes erythocephalus*	Red-headed woodpecker	G5	
Mammal	*Mephitis mephitis*	Eastern striped skunk	G5	
Mammal	*Microtus pennsylvanicus*	Meadow vole	G5	
Reptile	*Micrurus fulvius*	Eastern coral snake	G5	S2
Mammal	*Myotis austroriparius*	Southeastern myotis	G3,G4	S1
Invertebrate	*Neonympha areolatus*	Georgia satyr	G3, G4	
Mammal	*Neotoma floridana*	Eastern woodrat	G5	S3
Reptile	*Nerodia floridana*	Florida green water snake	G5	S2
Reptile	*Ophisaurus compressus*	Island glass lizard	G3, G4	S1
Bird	*Passerina ciris ciris*	Painted bunting	G5	S1
Reptile	*Pituophis m. melanoleucus*	Northern pine snake	G4	S3
Bird	*Plegadis falcinellus*	Glssy ibis	G5	
Amphibian	*Pseudobranchus striatus*	Dwarf siren	G5	S2
Mammal	*Sciurus niger*	Eastern fox squirrel	G5	
Bird	*Sitta pusilla*	Brown-headed nuthatch	G5	
Reptile	*Seminatrix pygaea*	Black swamp snake	G5	

Taxa	Common Name	Scientific Name	Global Rank	State Rank
Bird	*Tyto alba*	Barn owl	G5	S4
Mammal	*Ursa americanus*	Black bear	G5	S3
Invertebrate	*Zale perculta*	Okefenokee zale moth	G2	

5.4 Aquatic At-Risk Species

5.4.1.1 Preliminary Findings

►We are identifying lists of at-risk species and evaluating plan area ecological conditions for these species in the plan area. The set of at-risk species evaluated within this assessment includes:

1) Federally recognized threatened, endangered, proposed and candidate species.

2) Potential species of conservation concern. The planning rule requires that species of conservation concern be "known to occur in the plan area" and that the regional forester ultimately identify "species of conservation concern", for which "the best available scientific information indicates substantial concern about the species' capability to persist over the long term in the plan area."

►The 1996 Francis Marion Forest Plan has limited direction on the viability of aquatic at-risk species. The 2012 Planning Rule requires additional direction associated with aquatic at-risk species that is not addressed in the 1996 Francis Marion Forest Plan.

►Nineteen species of potential conservation concern were identified including nine fish, two crayfish, and eight mussels. Potential species of conservation concern include Natureserve-ranked G1-G3 and S1-S2 species, and species of greatest conservation need identified in the South Carolina Comprehensive Wildlife Conservation Strategy (see Table 5-6)

►Two federally endangered fish species and two fish candidate species for federal listing are found on the Francis Marion National Forest (see Table 5-6). An additional fish species has been petitioned for federal listing.

►The majority of the at-risk species habitats occur on the Forest, where the Forest Service has the capability to maintain suitable habitat. However, the two federally listed sturgeon species and striped bass occur only in the large rivers adjacent to National Forest land. Most of the lands adjacent to these rivers are in private ownership. Habitat management for these large river species is not within the jurisdiction of the Forest Service, but management activities that reduce impacts to water quality and instream habitat would contribute to the protection of large river habitats in those watersheds.

5.4.1.2 Direction in the 1996 Francis Marion Forest Plan

Forestwide Goal G-1 Provide for Forest Diversity (p. 1-2, FM Forest Plan)

"The Francis Marion National Forest is an environment similar to a puzzle in that it has many biological pieces. Our goal is to maintain and repair, where necessary, the integrity and value of these pieces especially endangered and threatened species habitat, disappearing natural communities, uncommon biological or ecological sites and other important elements of diversity."

Desired Future Condition (DFC) for Proposed, Threatened, Endangered and Sensitive Species (p. 1-4, FM Forest Plan)

"The Forest provides adequate habitat for various animals whose populations were previously threatened by dwindling population numbers."

Forest Objective O-13 (p. 2-2, FM Forest Plan)

"Maintain or expand existing proposed, endangered, threatened and sensitive (PETS), and Management Indicator Species and communities (MIS).

5.4.1.3 At-Risk Species

- At-risk species include federally listed, proposed and candidate species and potential species of conservation concern. Land Management Planning Handbook criteria used for the selection of potential aquatic species of conservation concern include the following.
- The species is known to occur on the forest.
- The best available scientific information indicates substantial concern about the species' capability to persist over the long term in the plan area. This includes G3 and S2 ranked species and species of greatest conservation need identified in the South Carolina Comprehensive Wildlife Conservation Strategy (Kohlsaat et al. 2005). American Fisheries Society publications (Jelks et al. 2008; Taylor et al. 2007; Warren et al. 2000; Williams et al. 1992) were also considered when selecting aquatic potential species of conservation concern.

  The majority of the at-risk species habitats occur on the forest, where the Forest Service has the capability to maintain suitable habitat (see Table 5-6). However, the two federally listed sturgeon species and striped bass occur only in the large rivers adjacent to forest land. Most of the lands adjacent to these rivers are in private ownership. The Santee and Cooper Rivers are both dammed and habitat within these two rivers is very dependent on the dam management. Habitat management for these large river species is not within the jurisdiction of the Forest Service, but management activities that reduce impacts to water quality and instream habitat would contribute to the protection of large river habitats in those watersheds.

5.4.1.4 Information Needs

- Road culvert inventory and stream layer map.
- GIS information by watershed based on a stream layer map: riparian acres; stream miles broken into perennial, intermittent and ephemeral; road and trail density; road and trail density in riparian areas.
- Aquatic organism passage survey and mapping.
- Instream habitat surveys.

Table 5-6. Aquatic at-risk species found on the Francis Marion National Forest

Scientific Name	Common Name	Status[1]	Aquatic Ecosystem Occurrence	
			Streams and Rivers	Lentic Systems
Federally Listed Species				
Fish				
Acipenser brevirostrum	shortnose sturgeon	E	x	
Acipenser oxyrinchus	Atlantic sturgeon	E	x	
Potential Species of Conservation Concern				
Fish				
Chologaster cornuta	swampfish	SCC	x	x
Anguilla rostrata	American eel	Petitioned	x	
Enneacanthus chaetodon	blackbanded sunfish	SCC	x	x
Enneacanthus obesus	banded sunfish	SCC	x	x
Alosa aestivalis	blueback herring	FC	x	x
Alosa pseudoharengus	alewife	FC	x	x
Notropis chalybaeus	ironcolor shiner	SCC	x	x
Elassoma evergladei	Everglades pygmy sunfish	SCC	x	x
Ameiurus catus	white catfish	SCC	x	x
Ameiurus platycephalus	flat bullhead	SCC	x	x
Morone saxatilis	striped bass	SCC	x	x
Etheostoma serrifer	sawcheek darter	SCC	x	x
Crayfish				
Procambarus ancylus	Coastal Plain crayfish	SCC	x	x
Procambarus enoplosternum	black mottled crayfish	SCC	x	x
Mussels				
Elliptio angustata	Carolina lance	SCC	x	
Elliptio complanata	Eastern elliptio	SCC	x	x

Scientific Name	Common Name	Status[1]	Aquatic Ecosystem Occurrence	
			Streams and Rivers	Lentic Systems
Elliptio congaraea	Carolina slabshell	SCC	x	
Elliptio fisheriana	Northern lance	SCC	x	
Elliptio icterina	variable spike	SCC	x	x
Elliptio roanokensis	Roanoke slabshell	SCC	x	
Lampsilis splendida	rayed pink fatmucket	SCC	x	x
Ligumia nasuta	Eastern pondmussel	SCC	x	x

[1] Status column: E = Federally Endangered, FC = Candidate Species for Federal Listing, Petitioned = petitioned for federal listing, SCC = Potential Species of Conservation Concern.

6 Social and Economic Assessment

6.1.1.1 Preliminary Findings

1. Populations surrounding the Francis Marion National Forest are rapidly changing as nearby Forest-dependent communities continue to experience rapid growth. Trends indicate that the region will become increasing more urban and home to even larger populations of retirees over the next 20 years. As populations surrounding the Forest change, community values and uses associated with the Francis Marion may change.
    - The area surrounding the Francis Marion is predominately urban and land development trends suggest that the area will likely become increasingly urban.
    - The population within the Francis Marion study area steadily grew between 1980 and 2010 (+60 percent). Population growth was unevenly distributed between the eight study area counties, ranging from 12 percent in Orangeburg to 166 percent in Horry County. Growth in Williamsburg has been more varied relative to the other counties. Between 1980 and 2010 Williamsburg's population declined by 10 percent, experiencing considerable population loss during the early 2000s.
    - Populations are forecasted to grow through 2030 and net migration is expected to play an increasing role in the region's anticipated growth.
    - South Carolina's population (median age 37.9) is slightly older than the general U.S. population (median age 37.2) and the population of the eight-county study area (average median age 39) is slightly older than the State's general population.
    - South Carolina has gained considerable attention in recent years as a retirement destination. Between 2007 and 2011 more than 10,000 people 65 years or older moved to South Carolina from another state or country. In-migration by older populations accounted for 6 percent of all new South Carolina residents over this 5-year period. As shown in Table 6-1, the 5 years between 2007 and 2011 brought large numbers of retirees to counties surrounding the Francis Marion as well. While the coastal County of Horry welcomed the greatest number of new residents 65+; the majority of the region's new residents 65 years or older settled in the Forest gateway counties[1] of Berkeley, Charleston, and Dorchester.
2. The natural amenities provided by the Francis Marion contribute to quality of life in local communities and are a driving force behind in-migration to the region.
    - Net migration accounts for the majority share of population change in the study area and accounts for more than half of all population change in Clarendon, Dorchester, Georgetown, Horry, and Williamsburg. Much of the region's in-migration can be attributed to the area's natural and cultural amenities.
    - Natural amenities, often provided by public lands, have been found to influence population and employment changes in amenity rich communities (Knapp and Graves 1989; Clark and Hunter 1992; Treyz et al. 1993; Mueser and Graves 1995; McGranahan 1999; Lewis et al. 2002). As a steward of coastal South Carolina's unique natural and cultural amenities, the Francis Marion increases the attractiveness of local communities and increases regional well-being.

[1] Forest gateway counties are those in close geographic proximity to national forest system lands and have been identified as having string social and economic ties to the Francis Marion.

3. Environmental justice populations have been identified within the Francis Marion National Forest's study area. Environmental justice populations often have differential patterns of consumption of natural resource and have an increased likelihood of experiencing disproportionately high and adverse effects related to changes in the management of Francis Marion resources.
    - South Carolina's population is more racially diverse than the general U.S. population due to its large African American population. While African Americans account for less than 15 percent of the total U.S. population, nearly 30 percent of the population in South Carolina and the eight-county study area are African American.
    - Relative to the general U.S. population, South Carolina and the eight-county study area had a slightly larger share of residents and families living below the poverty line in 2011. Poverty rates were exceptionally high in Clarendon, Georgetown, Orangeburg, and Williamsburg counties, and exceeded rates at both the State and national level.
4. The Francis Marion contributes to the sustainability of forest-dependent communities by cultivating a robust tourism and recreation industry and by continuing to support economic activity in local logging and wood manufacturing industries. The Forest also contributes to the liveliness of communities by facilitating shared traditions, culture, and activities among individuals belonging to several communities of interest.
    - Economic contributions of managing forest resources can be measured in terms of the jobs and income which they support in forest-related industries. Salary and non-salary regional office and district ranger office Forest expenditures supported 148 jobs (direct, indirect and induced) and approximately $8.7 million in local labor income across Berkeley, Calhoun, Charleston, Clarendon, Dorchester, Georgetown, Horry, Lexington, Orangeburg, Richland, and Williamsburg counties. In addition to employment and income contributions directly supported by Forest management expenditures, the Forest's resources contribute to economic activity in the local recreation and tourism and timber industries. In 2011 recreation-related spending by Francis Marion visitors was estimated to support 103 jobs and nearly $3.1 million in local income in the eight counties surrounding the National Forest. Timber and wood products from the Francis Marion were estimated to support 36 jobs and nearly $1.7 million in local wages and proprietor's income, and Secure Rural Schools and Community Self-Determination Act payments were estimated to support another eight jobs and more than $373,000 in labor income within Berkeley, Charleston, Clarendon, Dorchester, Georgetown, Horry, Orangeburg, and Williamsburg counties.
    - The natural amenities and recreational opportunities provided by the National Forest help support local tourism and recreation which is generally reflected by the wholesale and retail and accommodation and food services sectors. In 2011the government (17 percent), wholesale and retail trade (14 percent), and accommodation and food services (11 percent) sectors were the largest employers within the eight-county study area, accounting for 42 percent of total study area employment. A portion of employment in these sectors is directly attributed to the Forest's salary expenditures and by supporting recreational opportunities that stimulate spending in sectors related to recreation and tourism.
    - The Francis Marion can be attributed with contributing to the long-term sustainability of several communities of interest whose members share attitudes, values, and beliefs relating to recreation and Forest access, natural landscapes and

development buffer areas, historic and cultural significance, and timber and wood products.

6.1.1.2 Introduction

The Francis Marion National Forest is part of the Atlantic Coastal Forest Ecoregion. Residing in South Carolina's coastal plain the Forest is bounded to the north by Santee River, the Intracoastal Waterway and the Atlantic Ocean to the east. Managed as part of the Francis Marion and Sumter National Forests, the Francis Marion consists of 258,816 acres of upland forests, bottomland and hardwood swamps, maritime forests, salt marshes, and wetland impoundments in Berkeley and northeastern Charleston counties.

The lands which make up the Francis Marion have a rich history which predates European settlement. Although much of the area was once cleared for farming and wide-scale timber harvesting, the Forest has wild landscapes that provide habitat for native and endangered wildlife and supports an abundance of historical, cultural, and recreational opportunities. The Francis Marion features four wilderness areas, seven recreational areas, hundreds of miles of open roads and nearly 120 miles of trails which are used for hiking, horseback riding, mountain biking, off-highway motorized recreation and interpretation of the Forest's historical and cultural significance. Deer hunting with dogs, still deer hunting, small game hunting and turkey hunting are among the most popular activities on the Francis Marion; and its diverse network of waterways which connects slow moving blackwater creeks to the Atlantic Intracoastal Waterway allows visitors to boat, canoe, and fish the Forest's waterways.

To more effectively manage the Francis Marion's natural and cultural resources for current and future generations, the Francis Marion Ranger District is revising its 1996 Resource Management Plan. As part of the Forest's new RMP, this document will provide the social and economic context in which alternative management actions on the Francis Marion National Forest can be analyzed.

6.1.1.3 Existing Conditions

Located 140 miles east of the Forest supervisors' office in Columbia and 40 miles north of the Charleston, the Francis Marion includes the communities of Awendaw, Huger, Jamestown, and McClellanville. While few people live within the Forest boundaries, numerous nearby communities have longstanding social and economic ties to the natural and cultural resources of the Francis Marion. Since neighboring communities may be affected by forest management decisions on the Francis Marion, it is important to examine existing socioeconomic conditions of a broader region in order to establish a baseline in which potential impacts can be measured against. To more effectively examine the linkages between Forest Service lands and the local communities they serve, the geographic scope of this analysis has been expanded beyond Francis Marion boundaries to encompass a broader social and economic study area.

Communities within Berkeley, Charleston, Clarendon Dorchester, Georgetown, Horry, Orangeburg, and Williamsburg counties were recognized as having the strongest social and economic ties to the Francis Marion. While Francis Marion visitors travel from far and wide, residents of these eight counties were identified as having stronger ties and are most likely to be affected by changes in Forest management because of their reliance on Forest resources to sustain the social, cultural, and economic well-being of their communities. To more accurately measure the economic contributions and potential impacts resulting from changes in management actions on the Forest, the economic study was further extended to include Lexington, Richland, and Calhoun counties which surround the supervisor's office in the capital

of Columbia, South Carolina. The following "Existing Conditions" section will analyze trends and current conditions related to the social and economic environment within these study areas, including: population and demographic changes, potential environmental justice populations, and employment and income conditions. To ensure large-scale impacts are addressed without masking changes in smaller regions, this analysis uses a multidimensional approach to analyze trends at the state, aggregated study area, and individual county levels.

Population and Demographics

This section highlights population and demographic trends in the area surrounding the Francis Marion. Population is an important consideration in managing natural resources. In particular, population structure (size, composition, density, etc.) and population dynamics (how the structure changes over time) are essential to describing the consequences of Forest management on the social environment (Seesholtz et al. 2004).

Population Growth. Population growth can be an indicator of a region's desirability to live and work. As displayed in Table 6-1, the rapid population growth in South Carolina and the eight-county study area over the last 30 years suggests that this area is highly desirable to current and prospective residents. While the total U.S. population grew by 36 percent between 1980 and 2010, the State's population increased by 48 percent and total population within the study area increased by 60 percent (U.S. Census 2010).

Growth within the eight-county study area exceeded that of the State and Nation over the last 30 years, growing by 2 percent on annual average. While the population of the eight-county study area grew rapidly between 1980 and 2010, the rate of growth varied considerably between counties included in the study area. Over this 30 year period population growth within the study area was highly concentrated in Berkeley, Dorchester, and Horry counties, while the population of Williamsburg slowly declined. On average these counties grew by 3, 4, and 5 percent, respectively, while Williamsburg decreased by less than 1 percent annually (U.S. Census 2010).

Changes in a region's population can be attributed in part to natural increases (births minus deaths) and in part to net migration, which can affect the availability of housing, services, and jobs. Migration was the driving force behind much of the population change with the State (64 percent) and the study area (62 percent) between 1990 and 2010. Although migration accounted for more than half of net population change in the majority of the counties within the Francis Marion study area, natural changes were still the leading cause of population change in Berkeley (56 percent), Charleston (79 percent), and Orangeburg (97 percent) (Table 6-2) (U.S. Census 2011).

Table 6-1. Population totals: current and historic

	1980	1990	2000	2010	% Change 1980–2010
United States	226,545,805	248,709,873	281,421,906	308,745,538	36%
South Carolina	3,121,820	3,486,703	4,012,012	4,625,364	48%
8 County Area	722,308	847,298	962,760	1,155,951	60%
South Carolina Counties					
Berkeley	94,727	128,776	142,651	177,843	88%
Charleston	276,974	295,039	309,969	350,209	26%
Clarendon	27,464	28,450	32,502	34,971	27%
Dorchester	58,761	83,060	96,413	136,555	132%
Georgetown	42,461	46,302	55,797	60,158	42%
Horry	101,419	144,053	196,629	269,291	166%
Orangeburg	82,276	84,803	91,582	92,501	12%
Williamsburg	38,226	36,815	37,217	34,423	-10%

Source: U.S. Census Bureau, 1990, 2000, 2010.

Table 6-2. Components of population change between 1990 and 2010

	Natural Causes	Net Migration	Net Population Change 1990–2010	Percent Change from Natural Causes	Percent Change from Net Migration
South Carolina	412,067	726,987	1,139,054	36%	64%
8 County Area	116,625	192,025	308,650	38%	62%
Berkeley	27,699	21,486	49,185	56%	44%
Charleston	43,694	11,356	55,050	79%	21%
Clarendon	1,676	4,845	6,521	26%	74%
Dorchester	14,867	38,628	53,495	28%	72%
Georgetown	4,094	9,762	13,856	30%	70%
Horry	14,505	110,733	125,238	12%	88%
Orangeburg	7,447	250	7,697	97%	3%
Williamsburg	2,643	-5,035	-2,392	34%	66%

Source: U.S. Census Bureau, 2011 (Table 5).

Amenities (the natural, cultural, and social characteristics of an area) have played an increasing role in U.S. migration. Areas characterized as having high levels of natural amenities (unique land and water features, mild temperatures, scenic quality, and recreation opportunities of a geographic region) have been shown to experience greater population growth than areas with fewer natural amenities (Rudzitis and Johansen 1991; Johnson and Beale 1994; Johnson and Beale 1998; McGranahan1999; Hunter et al. 2005; Frentz et al. 2004), and that this growth occurs increasingly at the boundaries of public lands (Hansen et al. 1998; Radeloff et al. 2001). In recent years communities surrounding the Francis Marion, like those in Dorchester and Horry counties, have become increasingly attractive to many Americans because of their proximity to open spaces and natural settings which provide residents with easy access to recreational opportunities year round. As a steward of South Carolina's public lands, a portion of population

growth in this region can be attributed to the scenic beauty and outdoor recreation supported by the Francis Marion.

Future population projections suggest that migration will likely play an increasing role in population changes as national, State, and county populations grow. As shown in Table 6-3, South Carolina and the eight-county study area are projected to grow faster than the general U.S. population. Projections indicate that Berkeley, Dorchester, and Horry counties will continue to experience high levels of population growth while Williamsburg County is expected to experience further population loss (South Carolina Budget and Control Board 2013). These forecasts show that study area growth is anticipated to remain concentrated in communities which offer residents relatively easy access to recreation, open space and wildlands, provided by the Francis Marion.

Table 6-3. Population projections 2015–2030

	2015	2020	2025	2030	Growth Between 2010 and 2030
United States	321,363,000	333,896,000	346,407,000	358,471,000	16.1%
South Carolina	4,823,200	5,020,800	5,235,500	5,451,700	17.9%
8 County Area	1,218,500	1,280,800	1,344,500	1,408,400	21.8%
South Carolina Counties					
Berkeley	187,800	197,700	208,400	219,100	23.2%
Charleston	360,600	370,900	383,800	396,700	13.3%
Clarendon	35,600	36,300	37,400	38,600	10.4%
Dorchester	152,000	167,400	178,800	190,200	39.3%
Georgetown	61,300	62,500	63,800	65,100	8.2%
Horry	294,600	319,900	345,800	371,700	38.0%
Orangeburg	92,800	93,000	93,500	94,100	1.7%
Williamsburg	33,800	33,100	33,000	32,900	-4.4%

Source: http://www.census.gov/population/projections/data/national/2012/summarytables.html.

Population Density. Population density measures the number of people living per square mile within a given area. This measure can serve as a valuable indicator of the socioeconomic and living conditions of a region, including: urbanization, availability of open space, socioeconomic diversity, and civic infrastructure (Horne and Haynes 1999). In general, more densely populated areas tend to be more urban, diverse, and offer more access to public infrastructure. In contrast, less densely populated areas provide greater access to open spaces and wildlands, which may offer natural amenity values to residents and visitors. Table 6-4 displays the number of people per square mile at the county, State, and national levels (U.S. Census Bureau: State and County QuickFacts).

South Carolina has experienced substantial population growth over the last 30 years, causing the State to become much more densely populated than the nation as a whole. In 2010, nearly half of the counties included in the Francis Marion study area had twice as many people per square miles relative to population density for the nation (Table 6-4). While population densities surrounding the Francis Marion are high relative to the nation, population densities for Clarendon, Georgetown, Orangeburg and Williamsburg remain low (U.S. Census Bureau 2010).

Table 6-4. People per square mile

	2000	2010
United States	79.7	87.4
South Carolina	133.5	153.9
Berkeley	130.0	161.8
Charleston	337.5	382.3
Clarendon	53.5	57.6
Dorchester	167.8	238.2
Georgetown	68.5	73.9
Horry	173.4	237.5
Orangeburg	82.8	83.6
Williamsburg	39.9	36.8

Source: U.S. Census Bureau, 2010.

Population projections for the Lowcountry region of South Carolina indicate that region surrounding the Francis Marion will continue to grow through 2030. These population projections reflect continued urban, suburban, and ex-urban development, enabling counties surrounding the Francis Marion to become more densely populated. Growth within these counties is unlikely to be distributed evenly among local communities and can cause some areas to become more urban while others become increasingly more decentralized.

Although population density may indicate whether a county is classified as urban or rural, it is not a measure of the concentration of urban and rural areas within a county. Large disparities between urban and rural areas remain in terms of economic conditions, access to infrastructure and services—including public transportation, opportunities for socioeconomic mobility, and control over natural resources. Disparities are caused by natural differences, political decisions, and social factors. Figure 6-1 displays the distribution of urban and rural areas within study area counties.

Urban areas account for the majority of land surrounding the Francis Marion. In 2010, urban areas dominated five of the eight counties which make up the study area. Though little human development exists within Forest boundaries, urban growth has drastically altered the rural landscape of the region and caused growing concern over urban sprawl. Increasing residential and commercial development in Berkeley and Charleston counties has overrun many small, rural and unincorporated communities and has placed added pressure on the wildland-urban interface that separates the natural terrain of the Francis Marion from developed lands. Rapid urban expansion of the Charleston area during the 1990s gained considerable attention after county officials concluded that the rate at which land was being developed was unsustainable (Johnson et al. 2009). According to a 1997 report published by the Berkeley-Charleston-Dorchester Council of Governments (BCD COG), residential and commercial development in Berkeley, Charleston, and Dorchester counties had outpaced population growth by a ratio of 6:1 between 1973 and 1994. Though residents, community officials, and government agencies have been working together to mitigate the effects of continued urban growth in the region, the region surrounding the Francis Marion is anticipated to become increasingly more urban. Even assuming urban development would slow, the urban area surrounding the Charleston metropolitan area is predicted to triple by 2030 (Allen and Lu 2003).

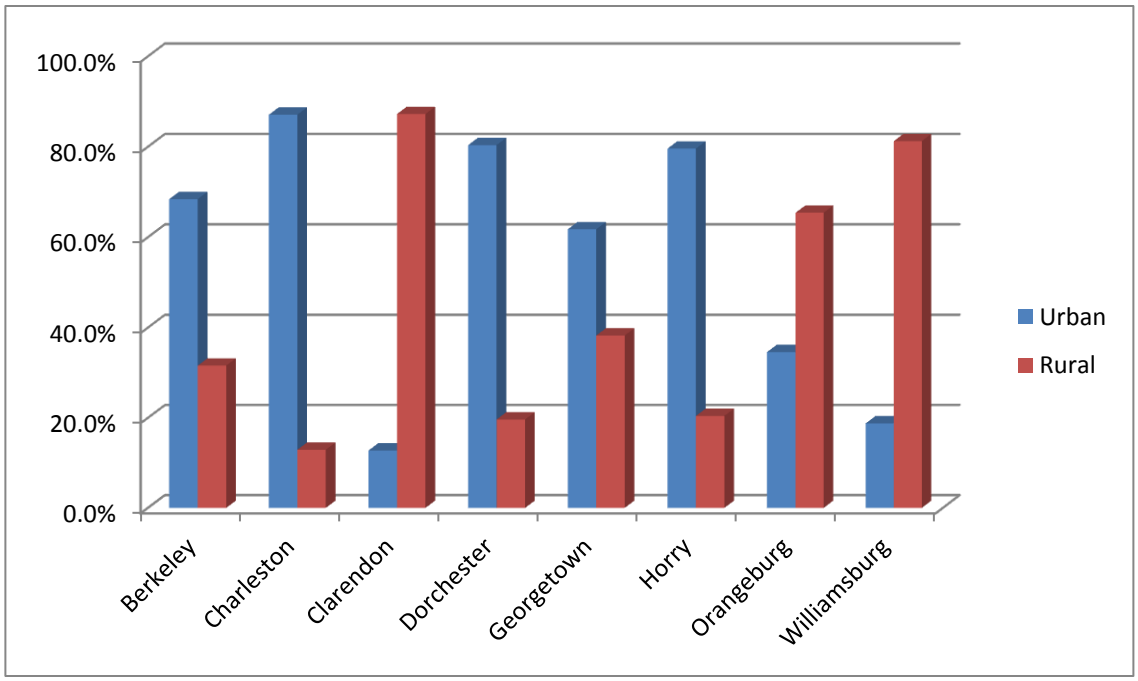


Figure 6-1. Urban-rural distribution, 2010

Source: U.S. Census Bureau (Table H2).

Growing populations and the encroachment of human development will place greater demand on Forest resources and may affect the natural aesthetics and uses associated with Francis Marion lands. Forest management can expect to be tasked with maintaining the quality of visitors' experiences while providing Forest products and unique cultural and recreational experiences to a greater number of people. As urban and suburban populations grow, conflicts between local residents and Forest visitors may increase.

While living proximate to public lands may provide local residents with amenities such as convenient access to recreation and wildlife viewing, increased Forest congestion causes disamenities such as crowds, litter, and noise (Garber-Yonts 2004; Bolitzer and Netusil 2000; Moore et al. 1992). Increased urbanization of areas surrounding the Francis Marion also increases the region's need for infrastructure and places greater pressure on Forest management to provide utility right-a-ways to meet the region's growing infrastructure needs which may have a negative effect on the visual resources of the Forest. The pressure of native landscapes to adapt to these conflicting pressures threatens the Forest's sense of place and the quality of life in communities surrounding the Forest (Stedman 2003).

Age. A population's age may affect community values and uses associated with Forest lands, making it relevant to Forest management decisions. In 2010 the median age in the United States was estimated to be between 37.2 and 37.9 in South Carolina (U.S. Census Bureau 2010). In general South Carolina's population is slightly older than the general U.S. population and the population of the eight-county study area is slightly older than the State's general population. Table 6-5 lists median ages within the study area.

In general, the United States is growing older. In 2010 there were 40.4 million Americans 65 years or older and America's older population (65 years +) is expected to reach 83.7 million and

account for nearly 21 percent of the country's population in 2050 (U.S. Census Bureau 2012). The graying of the U.S. is largely attributed to the post-WWII "baby boom generation" (those born between 1946 and 1964) who will start entering the 65+ demographic in 2011. Though many aging American's spend their retirement years in the homes and communities where they have raised families and worked, trends indicate that a sizable share of Americans 65+ have been moving to amenity-rich places which are characterized as having warmer average temperatures and lower rates of crime and taxes (Clark and Davies 1990; Conway and Houtenville 1998; McGranahan 1999; Serow 2000).

Table 6-5. Median age, 2010

	Berkeley	Charleston	Clarendon	Dorchester	Georgetown	Horry	Orangeburg	Williamsburg
Median Age	34.5	35.9	41.4	35.6	45.4	41.1	38.1	40.2

Source: U.S. Census Bureau, 2010.

South Carolina has gained considerable attention in recent years as a retirement destination. Between 2007 and 2011 more than 10,000 Americans 65 years or older moved to South Carolina from another State or country. In-migration by older populations accounted for 6 percent of all new South Carolina residents over this 5-year period (U.S. Census Bureau 2007–2011 American Community Survey). As shown by Table 6-6, the 5 years between 2007 and 2011 brought large numbers of retirees to counties surrounding the Francis Marion as well. While the coastal County of Horry welcomed the greatest number of new residents 65+; the majority of the region's new residents 65 years or older settled in the Forest gateway counties of Berkeley, Charleston, and Dorchester. As a steward of the natural and cultural amenities which make this area an attractive retirement destination, the Francis Marion can be attributed with attracting a share of migrating retirees and retirement income to the eight-county study area. As populations surrounding the forest grow older, community values and uses associated with the Francis Marion may change. In general, older Forest users demand more leisurely recreational experiences and have a greater need for easily accessible facilities than younger Forest users.

Table 6-6. Migration of individuals 65+, 2007–2011

Location	Moved from Another South Carolina County	Moved from Another State	Moved from Another Country
Berkeley	258	242	48
Charleston	367	821	57
Clarendon	0	59	0
Dorchester	380	297	0
Georgetown	136	143	85
Horry	187	1,368	84
Orangeburg	82	31	0
Williamsburg	13	42	0

Source: U.S. Census Bureau: American Community Survey (Table B07001).

Educational Attainment. Educational attainment measures the number of people within a region who have earned a high school diploma or bachelor's degree. Levels of education can be an important indicator of the social and economic opportunities and ability of an area to adapt to change. Table 6-7 lists the percentage of the adult population with at least a high school diploma and a bachelor's degree.

Table 6-7. Educational attainment, percent of persons age 25+

	High School Diploma +	Bachelor's Degree +
United States	85.4%	28.2%
South Carolina	83.6%	24.2%
Berkeley	86.0%	19.2%
Charleston	87.9%	37.7%
Clarendon	75.8%	13.4%
Dorchester	88.9%	24.6%
Georgetown	84.5%	22.0%
Horry	87.4%	21.9%
Orangeburg	78.4%	17.3%
Williamsburg	77.8%	11.3%

Source: U.S. Census Bureau, 2010.

While the majority of South Carolina adults have obtained at least a high school diploma, educational attainment in South Carolina is low relative to other areas of the country. While roughly 85 percent of the U.S. population holds a high school diploma and 28 percent have a Bachelor's degree or higher, only 84 percent of South Carolina residents 25 or older have completed high school and just over 24 percent have obtained at least an undergraduate degree. Educational attainment is exceptionally low in the rural counties of Clarendon, Orangeburg, and Williamsburg where less than 80 percent of residents over the age of 25 have high school diplomas and only a small fraction hold a Bachelor's degree or higher. Low educational attainment in rural areas is not uncommon. Since rural communities generally offer few opportunities for educational or occupational advancement they often struggle to retain and attract educated and highly skilled individuals. Frequently residents interested in pursuing advanced education move from these rural communities to more economically advanced areas which support greater educational opportunities. The out-migration of talented and educated residents is often referred to as "brain drain."

A large share of the region's institutions for higher education is located in Charleston County, with several two-year, four-year, and trade schools located in the Northern Charleston area. In general the population of Charleston County tends to be relatively more educated, with educational attainment rates exceeding those of the State and the county. In 2010 approximately 88 percent of Charleston County's population possessed high school diplomas and nearly 38 percent of its population held a Bachelor's degree or higher. The presence of so many highly educated adults may be self-reinforcing as a highly educated population tends to be a signal that an area provides economic and cultural opportunities, attracting additional college educated adults to the area. This process leads to further economic development and job creation. In contrast, areas with low levels of educational attainment tend to have lower levels of human capital, which reduce the area's ability to capitalize on economic change (Florida 2002).

Racial and Ethnic Composition. South Carolina's population tends to be more racially diverse than the general U.S. population. While 74 percent of the country's population identifies themselves as White, Whites only account for 67 percent of the State's population. Historically African American populations in South Carolina have accounted for a large share of the State's population. In 2010, roughly 28 percent of South Carolina residents identified themselves as Black or African American. While individual shares are small, Native Americans, Asians, Pacific Islanders, and individuals identifying with some other or multiple races account for nearly 5 percent of the State's population (U.S. Census Bureau 2010).

Minority populations make up an even larger share of the population within the eight-county study area. While shares of Native Americans, Asians, Pacific Islanders, and individuals identifying with some other or multiple races only make up 5 percent of the region's population, African Americans account for nearly 30 percent of the region's population (U.S. Census Bureau 2010). As a shown in Figure 6-2, there is considerable variation in the racial composition of study area counties.

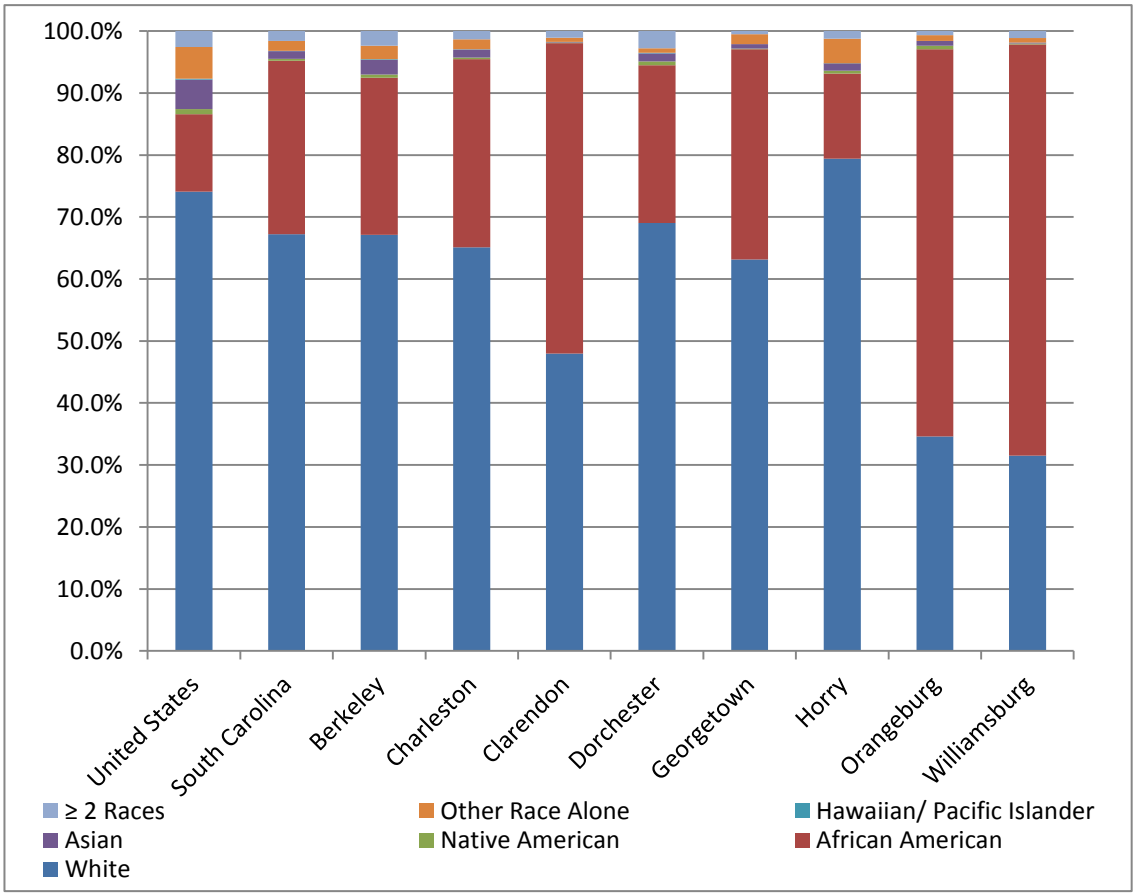


Figure 6-2. Racial composition, 2010

Source: U.S. Census Bureau, 2010 (Table QT-P6).

Figure 6-2 shows county, State, and national populations by racial group share of total population. Within the study area Horry County was the least racially diverse, with roughly 80 percent of the population identifying themselves as White alone; while Williamsburg was the most diverse with Whites accounting for only 32 percent of the population. The area surrounding the Francis Marion has a large African American population, with African Americans making up 50 percent or more of the population in Clarendon, 63 percent in Orangeburg, and 66 percent in Williamsburg.

Many Americans identify with racial groups based on physical attributes, but continue to be proud of the cultural heritage from which they descend. Although Americans may appear to look White, Black, Asian, or belonging to some other racial group, they often continue to speak the native language and follow cultural traditions from the regions where their families originated. This is especially common among Americans of Hispanic, Latin, or Spanish descent. In 2010, roughly 17 percent of Americans described their family ancestry as being Hispanic, Latin, or Spanish. While these cultures have a noticeable presence in the United States, only 5 percent of the State and study area's population reported being of Hispanic descent. Even though Hispanics accounted for a slightly greater share of the population in Berkeley (6 percent) and Horry (6 percent) counties, Hispanic cultures are less predominant in this region of the country relative to the United States as a whole (U.S. Census Bureau 2010).

Employment and Income

The previous section discussed demographics and population trends in counties surrounding Francis Marion National Forest relative to the State and nation. The following section will focus on economic conditions within the study area to further develop a baseline on which potential impacts can be measured.

Unemployment. Unemployment rates measure the percent of the local work force that is jobless but actively seeking employment. Though public officials strive for full-employment, structural unemployment (mismatch between labor skills and available jobs within a region) and frictional unemployment (people moving or transitioning employment) cause rates to persist even in times of economic prosperity. The existence of structural and frictional unemployment implies that there is an inherent "natural" rate of unemployment. The natural rate of unemployment is believed to fall somewhere between 5 and 6 percent and allows workers to move between jobs and industries without signaling broad economic distress. Figure 6-3 provides the annual unemployment rate of the study area relative to the State and Nation between 1990 and 2011.

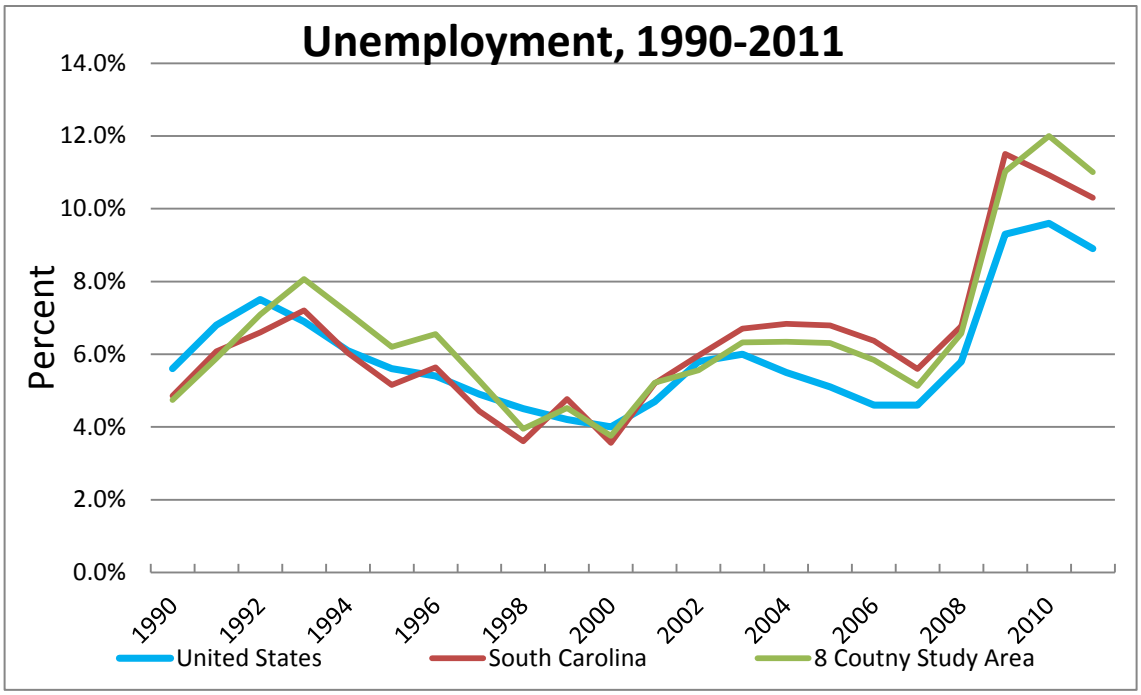


Figure 6-3. Unemployment 1990–2011

Source: Bureau of Labor Statistics, 2013.

Table 6-8. Unemployment in study area, 2005–2011

	Percent of Total Labor Force						
	2005	2006	2007	2008	2009	2010	2011
Berkeley	5.4	5.5	4.7	6.1	10.5	9.1	15.6
Charleston	5.5	5.0	4.3	5.3	9.0	11.7	9.1
Clarendon	9.8	9.1	8.3	9.7	15.4	15.8	16.0
Dorchester	5.3	5.0	4.3	5.6	10.0	16.0	12.1
Georgetown	8.7	7.0	6.1	7.4	12.2	11.5	12.4
Horry	5.8	5.5	5.0	7.0	12.0	14.2	11.1
Orangeburg	9.7	9.1	8.0	10.0	15.6	11.9	9.9
Williamsburg	11.2	9.8	8.9	10.3	14.9	18.8	11.4

Source: Bureau of Labor Statistics, 2013.

Historically, unemployment in the eight-county study area has closely mirrored Statewide trends and generally remains high relative to the national rate. The economic downturn in 2007 caused unemployment across the U.S. to rise, hitting South Carolina and the region surrounding the Francis Marion relatively hard. Since 2007, unemployment in the U.S has averaged 7.6 percent while average unemployment in South Carolina and the study area hovered around 9 percent. As shown in Table 6-8, unemployment drastically increased in 2009 as counties surrounding the Francis Marion witnessed an average increase of 4.8 percent in unemployment relative to 2008 rates. Although unemployment rates for Charleston and Orangeburg counties hover around those of the Nation, rates for the remaining five counties remain high relative to State and national statistics (Bureau of Labor Statistics 2013).

Employment and Specialization. The local economy examined in the analysis of the Francis Marion is diverse and supports employment in more than 300 industries. In general these industries are identified as being either services related or non-services related. Services-related sectors include: utilities; wholesale trade; retail trade; transportation and warehousing information; finance and insurance; real estate and rental and leasing; professional, scientific, and technical management of companies and enterprises; administrative and support services; educational services; health care and social assistance; arts, entertainment, and recreation; accommodation and food services; and other services. Non-services-related sectors consist of: mining, construction, manufacturing, and agriculture, forestry, fishing, and hunting.

Total employment in the eight-county study area increased from 348,044 to 377,939 jobs between 1998 and 2010. Though job creation is perceived as desirable, much of this growth can be attributed to growth in services-related industries which generally pay lower wages than those in non-services sectors. Study area jobs in service-related sectors paid on average 36 percent less than jobs in non-services-related fields (Bureau of Labor Statistics 2012). Between 1998 and 2010 employment in non-services-related sectors declined by 28 percent while employment in services related sectors increased by18 percent. In 1998 services-related sectors supported 79 percent of regional employment, with services-related employment growing to 86 percent of total employment in the eight counties surrounding the Francis Marion by 2010 (Bureau of Labor Statistics 2012). Although increases in services-related employment relative to non-services employment may have a negative effect on wages in the region, employment in the service sector may play an important role in increasing labor participation of the area's minority or underserved populations. In general, services-related sectors provide greater employment opportunities for women and minority racial groups than industries in the non-service sector, which may have a positive effect on the social and economic well-being of these communities.

Economic diversity generally promotes stability and offers greater employment opportunities. Highly specialized economies (i.e., those that depend on a few industries for the bulk of employment and income) are prone to cyclical fluctuations and offer more limited job opportunities. Assessing employment by sector helps identify industries which are important to the local economy surrounding the Francis Marion. Figure 6-4 shows local employment in aggregated sectors as a share of total employment (IMPLAN 2011). In 2011the government (17 percent), wholesale and retail trade (14 percent), and accommodation and food services (11 percent) sectors were the largest employers within the eight-county study area, accounting for 42 percent of total study area employment. A portion of employment in many of these industries can be directly or indirectly attributed to the Francis Marion. Employment contributions provided by the Francis Marion are discussed later in the "Forest Contributions" subsection.

The Interior Columbia Basin Ecosystem Management Project identified communities that were specialized with respect to employment. Employment specialization can be examined using the ratio of the percent employment in each industry in the region of interest (eight-county study area) to the percent of employment in that industry for a larger reference region (the State of South Carolina). For a given industry, when the percent employment in the analysis region is greater than in the reference region, local employment specialization exists in that industry (USDA Forest Service 1998). Applying this criterion to 2011 employment data for the Francis Marion study area reveals that the region is specialized with respect to the accommodations and food services (+3 percent), followed by the real estate and rental sector (+1.7 percent) and the arts, entertainment and recreation sector (+1.3 percent), retail trade (+0.6 percent), professional services (+0.4 percent), and transportation and warehousing (+0.3 percent).

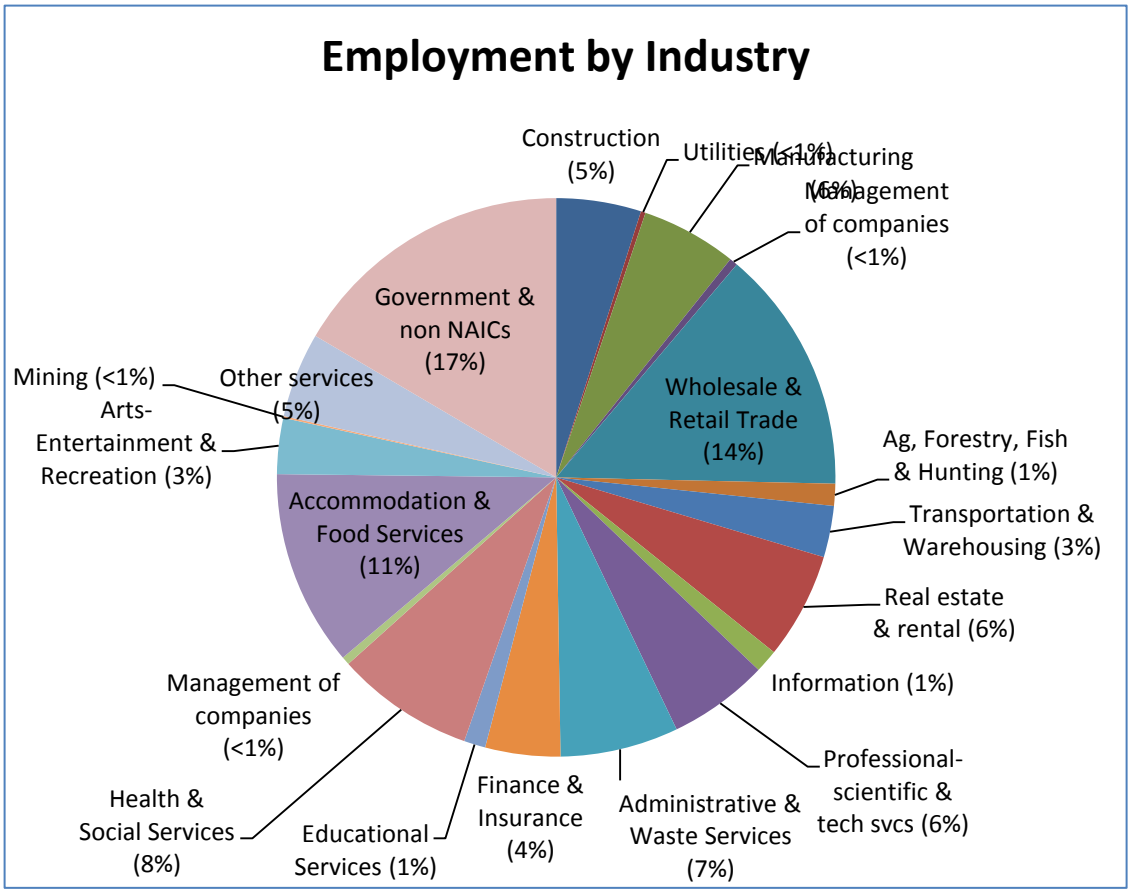


Figure 6-4. Employment by industry, 2011

Source: IMPLAN, 2011.

Employment specialization is of particular interest when specialization occurs in sectors related to forest management. A portion of employment in the sectors shown in Figure 6-5 can be attributed to forest management, timber production [2] and recreation on the Francis Marion. The government sector includes all Federal, state and local employment, while a portion of employment in the accommodations and food services, arts, entertainment and recreation, retail trade, and passenger transportation sectors is specifically attributed to tourism and recreation (Marcouiller and Xia 2008). Relative to the State of South Carolina, the eight-county local economy is less specialized in sectors related to forestry and more specialized in the service-related sectors that support recreation and tourism. Specialization in the four recreation- related sectors highlights the importance of tourism and recreation to the local economy. While the Charleston area provides an abundance of recreational opportunities, the unique recreational experiences of the Francis Marion are attributed with attracting outdoor recreationists to the Charleston area. For a more detailed discussion of the Forest's recreation-related employment contributions see the "Recreation" section included in "Forest Contributions".

[2] Sectors related to timber include: Forestry and logging (IMPLAN; sectors 15, 16, 19, 335), primary forest products manufacturing (IMPLAN; sectors 31, 95, 96, 98, 105), and secondary forest products manufacturing (IMPLAN; sectors 97, 99, 100, 102, 106, 107, 108, 109, 110, 111, 112, 295, 297, 301, 302) (BBER 2010).

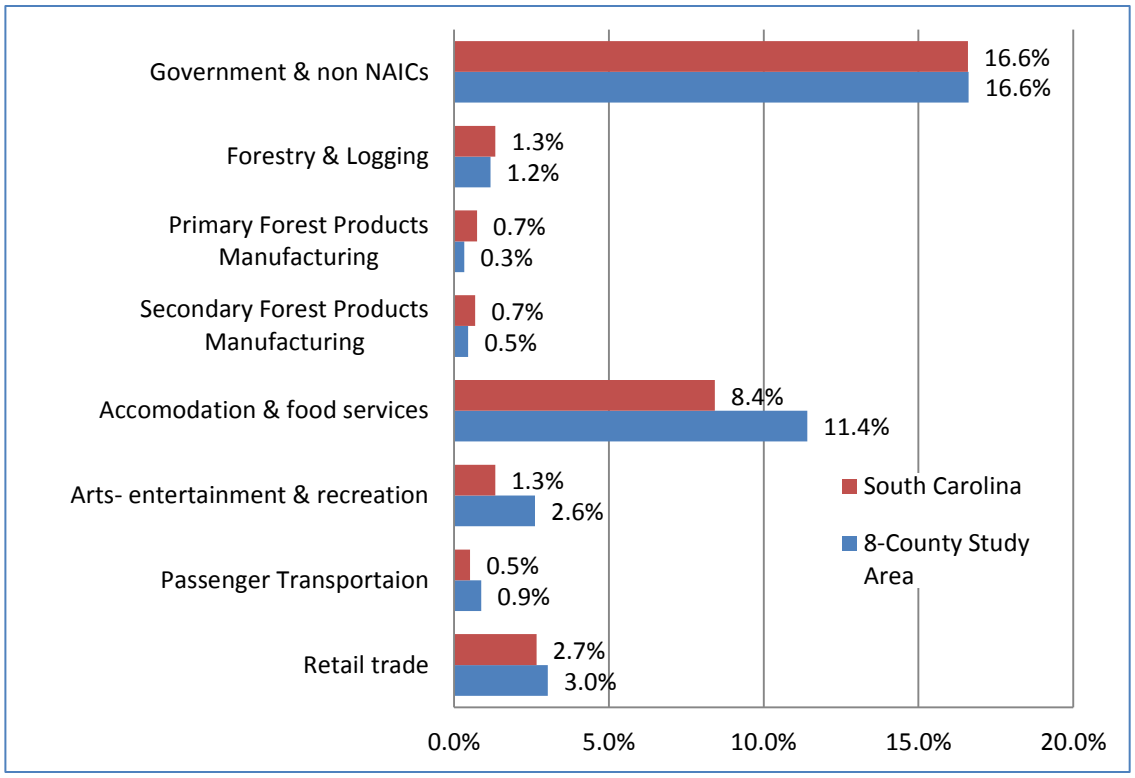


Figure 6-5. 2011 State and study area employment distribution for forest-related sectors

Source: IMPLAN 2011

Personal Income. Personal income is a key indicator of the economic well-being of a county and provides a measure of all sources of income within the study area. High personal income may be a signal of greater job opportunities, highly skilled residents, greater economic resiliency, and well-developed infrastructure. Low personal income is often a reflection of the poor economic conditions and relatively few economic opportunities available within a region. Total personal income (TPI) in the study area exceeded $41.3 billion dollars in 2011, with Charleston County accounting for more than one-third of the study area's TPI. Personal income in the study area has grown much more rapidly than TPI across the State. Between 2000 and 2011 total personal income in South Carolina grew by 18.6 percent while TPI within the eight-county study area grew by 30.4 percent (adjusted for inflation and reported in 2011 dollars) (Bureau of Economic Analysis 2012).

Per capita personal income (PCPI) measures average income per person in a region. Historically PCPI in South Carolina and much of the region surrounding the Francis Marion National Forest has been lower than that across the country. As shown by Table 6-9, PCPI across the State and country has steadily increased between 1990 and 2011. While PCPI at the State level grew at a slightly slower rate than that of the Nation, per capita personal income across the study area occurred much more rapidly. On average PCPI rose by 32 percent across the study area between 1990 and 2011, with sluggish growth in Horry County (+9 percent) and very rapid growth in Georgetown County (+51 percent). Though personal income in the region has increased, average PCPI within the study area remains below that of the State and the country (Bureau of Economic Analysis 2012).

Table 6-9. Per capita income, 1990 and 2011 (adjusted for inflation and reported in 2011 dollars)

	1990	2011	% Change 1990–2011
United States	33,309	41,560	25%
South Carolina	27,268	33,388	22%
Berkeley	24,402	33,184	36%
Charleston	30,400	41,656	37%
Clarendon	18,998	24,431	29%
Dorchester	27,251	33,468	23%
Georgetown	25,420	38,403	51%
Horry	26,698	29,148	9%
Orangeburg	22,663	28,965	28%
Williamsburg	18,630	27,263	46%

Source: Bureau of Economic Analysis, 2012.

There are two major sources of personal income: (1) labor earnings or income earned through employment and (2) non-labor income. Labor earnings, or wages, were supported by a wide range of industrial sectors and represented 63 percent of the study area's TPI in 2011. Although wages can fluctuate between counties and across industries, average annual wage in the Francis Marion National Forest study area remain well below those of the State and the Nation. In 2011 the average annual wage in the eight-county study area was $34,716, ranging from $27,885 in Clarendon County to $43,744 in Berkeley County (Table 6-10). On average, study area jobs in service-related sectors paid 36 percent less than jobs in non-services-related fields.

Table 6-10. Average annual wages, 2011

	Average Annual Wage ($)		
	All Sectors	Services	Non-Services
United States	49,049	46,983	57,397
South Carolina	39,231	35,731	49,030
Berkeley	43,744	38,522	59,027
Charleston	42,354	37,417	58,982
Clarendon	27,885	22,930	31,223
Dorchester	33,109	26,416	53,621
Georgetown	34,815	27,604	49,792
Horry	29,089	25,999	38,162
Orangeburg	33,419	26,611	39,793
Williamsburg	33,316	26,958	40,369

Source: Bureau of Labor Statistics, Quarterly Census of Employment and Wages, 2012.

Using the same criterion utilized above to examine employment specialization, labor earnings in Berkeley, Charleston, Clarendon, Dorchester, Horry, Georgetown, Orangeburg, and Williamsburg counties were most specialized in the government/non-NAICS sector (+3 percent), accommodation and food service (+2 percent), and arts, entertainment and recreation (+1 percent) (IMPLAN 2011). Income specialization in these sectors provides further evidence of the linkages between the Francis Marion National Forest and local economies. While management expenditures support income for local Forest Service employees, the Forest's natural and cultural

amenities stimulate recreation and tourism spending which generates income in services-related industries. In this manner, a portion of local income specialization can be directly attributed to the Francis Marion National Forest.

While the local economy surrounding the Francis Marion National Forest supports a large share of lower paying service jobs, the unique natural and cultural amenities of the Forest may provide addition benefits which help offset these low wages. Living in close proximity to national forest lands provides residents with greater access to open spaces, wildlands, and a wide range of recreational opportunities. While local residents may forego higher paying jobs in areas with fewer natural amenities, they gain personal enjoyment from the outdoor experiences they have on the Francis Marion. In this manner some residents may earn a "secondary income" from local natural amenities which complements the income they earn through traditional employment. Natural amenities, often provided by public lands, have been found to influence population and employment changes in amenity rich communities (Knapp and Graves 1989; Clark and Hunter 1992; Treyz et al. 1993; Mueser and Graves 1995; McGranahan 1999; Lewis et al. 2002). As a steward of coastal South Carolina's unique natural and cultural amenities, the Francis Marion National Forest increases the attractiveness of local communities and increases regional well-being.

Non-labor Income. Personal income also includes non-labor income individuals receive from sources other than an employer. In general there are two categories of non-labor income, investment income (dividends, interest, and rent payments) and transfer payments from the government to individuals (retirement and disability insurance, medical payments, welfare assistance, unemployment, and veteran's benefits). Non-labor income's share of TPI has grown drastically in recent years. In 1970 non-labor income accounted for nearly 18 percent of TPI within the study area and the State of South Carolina. By 2011 non-labor income had grown to represent more than 37 percent of TPI in these regions (Bureau of Economic Analysis 2012).

Non-labor income's increasing share of regional TPI can be attributed to increases in both investment income and transfer payments. Between 1970 and 2011 investment income as a share of TPI within the study area grew from 10 percent to 15 percent while transfer payments increased from 8 percent to 23 percent. As shown in Table 6-11, there was considerable variation in the forms of non-labor income and their share of TPI across counties in the study area. While investment income accounted for a sizable share of TPI in Charleston, Georgetown, and Horry counties, transfer payments generally represented a larger share of TPI across the study area (24 percent). Transfer payments in the study area played a more significant role in supporting personal income than at the State or national level, with age and income maintenance payments contributing a larger share of TPI (Bureau of Economic Analysis 2012).

As discussed earlier in the demographics section, the population surrounding the Francis Marion National Forest is slightly older than the general population and the region's median age is likely to continue to rise. As the region's "baby boom" population grows, age-related transfer payments as a share of income from non-labor sources is likely to rise. Since communities with more retired residents are typically less dependent on employment as a source of income, communities with aging populations may be more resilient to economic downturns (USDA-Forest Service 2010).

Table 6-11. Non-labor income as a share of total personal income, 2011

			Percent of Total Personal Income		
	Total Personal Income ($1,000)	Non-labor Income Share	Investment Income	Age-related Transfer Payments	Income-maintenance-related Transfer Payments
United States	$13,221,853,005	34%	16%	10%	5%
South Carolina	$159,511,644	37%	14%	14%	6%
Study Area	$41,355,058	38%	15%	13%	6%
Berkeley	$6,218,020	27%	9%	10%	4%
Charleston	$15,213,359	35%	18%	10%	4%
Clarendon	$866,192	51%	13%	21%	14%
Dorchester	$4,814,413	28%	9%	11%	5%
Georgetown	$2,352,229	51%	21%	21%	7%
Horry	$8,224,006	46%	18%	18%	6%
Orangeburg	$2,718,079	44%	11%	16%	11%
Williamsburg	$948,760	48%	10%	18%	14%

Source: Bureau of Economic Analysis (Tables CA05N & CA35).

Rural county population change, the development of rural recreation, and retirement-destination areas are all related to natural amenities (Knapp and Graves 1989; Clark and Hunter 1992; Treyz et al. 1993; Mueser and Graves 1995; McGranahan 1999; Lewis et al. 2002). As a steward of natural amenities the Francis Marion National Forest can be consequently be attributed with attracting a portion of retirees and age-related non-labor income to the region; thus the Francis Marion National Forest may play a role fostering a more resilient economy.

Poverty. Poverty is an import indicator of both economic and social well-being. Individuals with low incomes are more vulnerable to a number of hardships which may negatively affect their health, cognitive development, emotional well-being, and school achievement, and promote socially unacceptable behavior (Williams 1984; Patterson 1991; Haan et al. 1986; Battistich et al. 1995; Farrington 1995; Chung 2004; Booth and Caan 2005; and Hopson and Lee 2011). Following the Office of Management and Budget's Directive 14, the Census Bureau uses a set of income thresholds that vary by family size and composition to detect who is poor. If the total income for a family or an individual falls below the relevant poverty threshold, then the family or an unrelated individual is classified as being “below the poverty level.”

Table 6-12. Poverty rates, 2011

	People Below Poverty	Families Below Poverty
United States	14%	10%
South Carolina	17%	13%
Berkeley	14%	11%
Charleston	17%	12%
Clarendon	21%	16%
Dorchester	12%	10%
Georgetown	21%	14%
Horry	17%	12%
Orangeburg	25%	20%
Williamsburg	33%	27%

Source: U.S. Census Bureau, 2012.

Relative to the general U.S. population, South Carolina and the eight-county study area had a slightly larger share of residents and families living below the poverty line in 2011 (Table 6-12). Poverty rates were exceptionally high in Clarendon, Georgetown, Orangeburg, and Williamsburg counties, and exceeded rates at both the State and national level (U.S. Census Bureau 2012). In general, low income individuals tend to rely more heavily on natural resources and depend more directly on national forest lands for sustenance and home heating. Since these individuals will be more vulnerable to changes in the management of local resources, it is important for Forest management to understand how these Forest users may be affected by restricting Forest uses.

Environmental Justice

In 1994, President Clinton issued Executive Order 12898. This order directs Federal agencies to focus attention on the human health and environmental conditions in minority and low-income communities. The purpose of EO 12898 is to identify and address, as appropriate, disproportionately high and adverse human health or environmental effects on minority and low-income populations.

Environmental justice is the fair treatment and meaningful involvement of people of all races, cultures, and incomes, with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies. The goal of environmental justice is for Federal agency decision-makers to identify impacts that are disproportionately high and adverse with respect to minority and low-income populations and identify alternatives that will avoid or mitigate those impacts. According to USDA DR5600-002 (USDA 1997), environmental justice, minority, minority population, low-income, and human health and environmental effects, are defined as follows:

> *Environmental justice* means that, to the greatest extent practicable and permitted by law, all populations are provided the opportunity to comment before decisions are rendered on, are allowed to share in the benefits of, are not excluded from, and are not affected in a disproportionately high and adverse manner by, government programs and activities affecting human health or the environment.
>
> *Minority* means a person who is a member of the following population groups: American Indian or Alaskan Native; Asian or Pacific Islander; Black, not of Hispanic origin; or Hispanic.

Minority population means any readily identifiable group of minority persons who live in geographic proximity to, and, if circumstances warrant, migrant farm workers and other geographically dispersed/transient persons who will be similarly affected by USDA programs or activities.

Low-income population means any readily identifiable group of low-income persons who live in geographic proximity to, and, if circumstances warrant, migrant farm workers and other geographically dispersed/transient persons who will be similarly affected by USDA programs or activities. Low-income populations may be identified using data collected, maintained and analyzed by an agency or from analytical tools such as the annual statistical poverty thresholds from the Bureau of the Census' Current Population Reports, Series P-60 on Income and Poverty.

Human health and/or environmental effects as used in this Departmental Regulation includes interrelated social and economic effects.

The emphasis of environmental justice is on health effects and/or the benefits of a healthy environment. The CEQ has interpreted health effects with a broad definition: "Such effects may include ecological, cultural, human health, economic or social impacts on minority communities, low-income communities or Indian Tribes …when those impacts are interrelated to impacts on the natural or physical environment" (CEQ 1997).

Based on the data presented in the previous sections relating to population demographics and employment and income, it is evident that environmental justice populations exist within the Francis Marion National Forest's study area. Census data indicated that the area surrounding the Francis Marion National Forest included high concentrations of African American and low income populations, increasing the likelihood of these groups experiencing disproportionately high and adverse effects related to changes in the management of Francis Marion National Forest resources. To mitigate adverse impacts on environmental justice populations Forest management may need to facilitate additional public outreach in these communities to ensure that environmental justice populations are involved in scoping and alternative development.

Forest Users and Contributions

Communities Interested in Francis Marion National Forest Management. Communities within the eight-county study area can be described by the areas they live in and by their connections to the local landscape. When we look at the effects of Federal land management actions, the most critical impacts are often felt by small, rural communities (USDA USFS 2000). Consequently, geographically defined communities are an important and relevant level for social assessment. However, the geographically based community refers to physical or political boundaries and not to the relationships among people who reside within these boundaries. Brown and Duguid describe communities of interest as "communities-of-communities" (Brown and Duguid 1991); they provide unique opportunities to explore the linkages between people and public land that may transcend the geographically defined community. Comments received during internal discussions with the Forest in support of this Forest plan revision indicate that communities of interest exist for individuals and groups[3] interested in:

- outdoor recreation and Forest access
- natural landscapes and scenic beauty

[3] Identified communities are not mutually exclusive; for example, individuals and groups interested in non-motorized recreation opportunities may also include individuals interested in animal and plant habitat.

- wildlife
- historic and cultural significance
- timber and wood products

Forest Contributions. The Francis Marion is managed in accordance with the Multiple-Use Sustained-Yield Act of 1960 (16 U.S.C. 528–531) to sustain the multiple uses of its renewable resources while maintaining the long-term health and productivity of the land. The Francis Marion National Forest's resources are managed for the long-term social and economic benefit of human communities. Economic benefits of managing Forest resources can be measured in terms of the jobs and income which they support in forest-related industries. In addition to employment and income contributions directly supported by Forest expenditures and employment, the Forest's resources directly contribute to economic activity in the local recreation and tourism and timber industries which in turn stimulates economic activity in supporting and non-forest related sectors. Employment and labor income generated in these seemingly unrelated sectors are known as the secondary, or indirect and induced effects of economic activity supported by the Forest.

Recreation. South Carolina's diverse geography and abundance of natural amenities have played an important role in making the State a retirement and recreational and tourist destination. Significant growth in services-related industries in recent years highlights the growing economic importance of the State's tourism industries and suggests that the economic drivers of the State have shifted away from agriculture-related industries towards those related to tourism and recreation. According to South Carolina's 2008 State Comprehensive Outdoor Recreation Plan (SCORP), the State hosts approximately 29 million domestic visitors and nearly 1 million international visitors annually. In 2008 the State's tourism and travel industry was estimated to account for approximately 9 percent ($10.9 billion) of South Carolina's Gross State Product (GSP) and supported more than 216,000 jobs within the State, and forecasted that tourism would account for a growing share of the State's economic activity over the foreseeable future (SCORP 2008). Outdoor recreation is attributed with playing an integral role in South Carolina's flourishing tourist industry. More than 11 million South Carolina visitors annually are estimated to participate in some form of outdoor recreation during their trip. Coupled with heritage and cultural tourism, outdoor recreation is believed to provide significant economic benefits to all regions of the State, especially to rural communities (SCORP 2008).

The Francis Marion supports a wide range of outdoor experiences which attracts thousands of local and non-local visitor's to the Forest each year. According to recent results from the National Visitor Use Monitoring (NVUM) program the Francis Marion National Forest supports approximately 431,903 visits a year. As shown by Table 6-13[4] , people visit the National Forest to participate in activities such as fishing, hiking, boating, mountain biking, camping, horseback riding, canoeing, wildlife viewing, and interpretation of historical sites. Deer hunting with dogs, still deer hunting, small game and turkey hunting are among the most popular activities on the

[4] U.S. Forest Service manages South Carolina's Francis Marion National Forest and Sumter National Forest as one administrative unit. Although they are two distinct national forests, they are treated as a singular Forest for all intents and purposes. Although subforest total visitation was able to be estimated from NVUM data using the White (2007) method, forest participation rates by activity are reported by forest and cannot be scaled down to subforest units. While actual activity participation rates on the Francis Marion may be higher or lower than rates reported for the Francis Marion-Sumter National Forests, it is reasonable to assume that recreation participation rates on the Francis Marion are comparable to those reported for the administrative unit.

Francis Marion with 21 percent of visitors reporting hunting as the primary reason for their Forest visit.

Opportunities for recreational, cultural, and leisure activities provided by the Francis Marion are unique and are attributed with attracting and maintaining local and non-local visitor spending in the local eight-county economy. Visitors traveling to the Forest to recreate often eat in local restaurants, shop in local retailers, and purchase gas and lodging. If recreational opportunities on the Francis Marion National Forest did not exist, recreationists and their recreation-related spending would likely travel elsewhere. In this manner the recreational opportunities supported by national forest lands contribute to the local economy by attracting and maintaining visitor spending in communities surrounding the Forest.

Table 6-13. Activity participation on the Francis Marion-Sumter National Forests

Activity	% Participation	% Main Activity
Relaxing	52.1	0.8
Viewing natural features	26.6	5
Viewing wildlife	25.9	3.6
Other non-motorized	25.8	18.1
Hiking/walking	23.1	4.2
Hunting	23	21.3
Driving for pleasure	21.8	2.8
Motorized trail activity	21.3	11.4
OHV use	17.1	4.3
Some other activity	10.1	9.8
Picnicking	9.5	2
Fishing	8.3	4.8
Non-motorized water	8	6.5
Developed camping	4	0.2
Nature center activities	3.4	0.9
Nature study	3.3	0.2
Visiting historic sites	2.6	0
Bicycling	1.9	0.1
Horseback riding	0.9	1
Motorized water activities	0.7	0.2
Gathering forest products	0.7	0
No activity reported	0.2	3.1
Other motorized activity	0.1	0
Primitive camping	0.1	0
Backpacking	0.1	0

Source: USDA Forest Service, NVUM, 2011.

Recreational and wildlife related experiences on the Francis Marion National Forest are an important attraction which draws visitors to the region. Visitors traveling to the Forest to recreate often eat in local restaurants, shop in local retailers, and purchase gas and lodging. Spending by Forest visitors is attributed with supporting jobs and income in gateway communities which

surround the National Forest. In total spending by recreationists on the Forest supports approximately 103 local jobs and nearly $3.1 million in labor income in the eight counties surrounding the National Forest. On an annual average basis approximately 77 of these jobs and $1.8 million of the labor income attributed to Forest recreation is supported in the accommodation and food services; arts, entertainment, and recreation; and retail trade sectors (IMPLAN 2011).

While providing recreation opportunities to local residents is an important contribution, recreation expenditures made by locals does not introduce new money into the local economy. If recreational opportunities on the Forest were not available, residents would likely substitute Forest recreation for other locally based activities and continue to make recreational expenditures locally. Non-local visitation to the Francis Marion National Forest injects new money into communities surrounding the Forest and generates local employment and income which may not exist in the local economy otherwise. On an annual average basis recreation-related expenditure by non-local Forest visitors supports 42 jobs and approximately $1.2 million in labor income within the eight-counties surrounding the Francis Marion National Forest (IMPLAN 2011).

Timber & Forest Products. Forest products have played an important role in South Carolina's history and economy. Dating back to early colonial America, the timber industry is one of the State's oldest and most successful industrial sectors. Timber continues to be the top ranked cash crop in 45 of the State's 46 counties. With more than 13 million acres of South Carolina's forest used for the production of commercial wood products, the delivered value of products harvested from timberlands across the State was valued at nearly $679 million in 2009. Economic activity associated with timberlands is can be attributed with making the State's forestry and wood products industry was the State's largest manufacturing industry in 2010, employing approximately 9,624 people with a payroll of $4.1 million (South Carolina Forestry Commission 2011). Forestry, logging, and wood processing also play an important role within the eight-county analysis area. Of the 5.2 million acres of land which make up the analysis area, approximately 3.1 million of these acres were timberlands (South Carolina Forestry Commission 2011) which are attributed with supporting more than 7,000 forestry and logging jobs within the Francis Marion National Forest analysis area in 2011 (IMPLAN 2011).

In accordance with the Multiple-Use Sustained-Yield Act, the Francis Marion is managed to ensure that the Forest continues to achieve and sustain a high level of timber production. The timber and wood products grown and harvested from the Francis Marion National Forest bolster the region's timber industry and contribute to the social and economic well-being of the region. In 2011 271 CCF of sawtimber, 274 CCF of pulpwood, 7,186 CCF of smaller non-saw timber products (which include pulpwood and chip and saw), and 25 CCF of fuelwood were harvested from the Francis Marion (USDA NRM 2012). While timber and wood products from national forest lands account for only a small share the region's timber, forest products from the Francis Marion National Forest directly support employment in logging and wood manufacturing firms in the area and indirectly contribute to employment in number of other industrial sectors (Table 6-14). It is estimated that timber and wood products from the Francis Marion support a total of 36 local jobs and nearly $1.7 million in wages and proprietor's income across the eight-county analysis area (IMPLAN 2011). Approximately 15 of these jobs and $934,000 of local labor income is supported in the agriculture and manufacturing sectors, these sectors include firms which specialize in forestry and logging and primary and secondary forest product processing.

Forest Expenditures and Employment

Management of the Francis Marion National Forest directly contributes to the local economy by employing individuals living within the area and by spending federally appropriated dollars on goods and services to carry out management programs. In recent years expenditures on Forest programs and personnel for the Francis Marion have averaged $10.4 million a year. Program-related expenditures do not include expenditures associated with emergency fire suppression since these cannot be considered consistent contributions to the area economy.

Although field support for the Francis Marion comes from the district ranger's office in Huger, financial and administrative support for the Forest is provided by the Forest supervisor's office in Columbia, South Carolina. On an average annual basis, expenditures associated with the management of the Francis Marion support 148 jobs (direct, indirect, and induced) and approximately $8.7 million in local labor income in the 11 counties which surround the Francis Marion National Forest and supervisor's office. These counties include Berkeley, Calhoun, Charleston, Clarendon, Dorchester, Georgetown, Horry, Lexington, Orangeburg, Richland, and Williamsburg counties (IMPLAN 2011).

Payments to States and Counties. While National Forest lands accounts for 5 percent of the land within the eight-county study area, 25 percent of Berkeley County and 10 percent of Charleston County is National Forest land. The Forest Service makes payments to states and counties that contain National Forest lands. These payments fall into two categories: Payments in Lieu of Taxes (PILT) and Secure Rural Schools and Community Self-Determination Act payments (SRSCS) (Table 6-14).

Federal agencies do not pay property taxes; therefore, PILT is distributed to counties to compensate for the local services that support activities on Federal lands. These services include law enforcement, road maintenance, and fire departments.

SRSCS payments redistribute a share of revenue generated from activities on Forest Service lands back to the counties. These payments are intended to improve public schools, maintain infrastructure, improve the health of watersheds and ecosystems, protect communities, and strengthen local economies. SRSCS payments are estimated to support eight jobs and more than $373,000 in local income in the eight-county study area (IMPLAN 2011).

Table 6-14. Payments to states and counties from the Francis Marion National Forest, 2012

	SRSCS (FY12)	PILT (FY12)	Total Payments Associated with NFS Land
Berkeley County	$412,518	$66,015	$478,533
Charleston County	$85,687	$22,145	$107,832
Francis Marion NF	$498,205	$88,160	$586,365

Source: USFS (2011) and DOI (2010).

Non-market Values. The true value of the Francis Marion National Forest is equal to the value of all goods and services it provides society. Generally goods and services are traded in markets where interactions between buyers and sellers determine the price, or value, of a good based on unit prices and the quantities sold. While the natural resources within the Francis Marion National Forest produce a wide range of environmental goods and services, markets in which these forest products can be bought or sold do not always exist. Some goods, like forage for cattle, can easily be valued because livestock feed can be bought and sold in markets. Other

resources on the Francis Marion National Forest, like sites of cultural or historic significance, recreational opportunities, ecological processes, and scenic views cannot be bought and sold in traditional markets, which is why these resources are often characterized as non-market goods. Although the public benefits from these goods, the lack value in the traditional sense of market prices often causes these resources to be undervalued.

Non-market values can be broken down into two categories, use and non-use values. The use-value of a non-market good is the value individuals receive from the direct use of natural resource or non-market good. Within the Francis Marion National Forest use-values exists for recreational activities such as hunting, hiking, canoeing, and wildlife viewing. The use of non-market goods often requires consumption of associated market goods, such as food, gas and lodging expenditures incurred by Forest visitors.

Non-use, or passive use, values of a non-market good reflect the value of an asset beyond its current use. These can be described as existence, option and bequest values. Existence values are the amount society is willing to pay to guarantee that an asset simply exists. An existence value for the Francis Marion National Forest might be the value of knowing that undisturbed native plant habitat exists or the value associated with undeveloped scenic landscapes. In addition to implicit existence values, society's willingness to pay to preserve resources for future use attaches additional passive use values. The potential benefits people would receive from future use are referred to as option values when future use is expected to occur within the same generation and bequest values when preservation allows future generations to benefit from the resource use. Within the Francis Marion National Forest bequest and option values might exist for numerous plant species, wild and scenic rivers and landscapes, historical sites, and recreational trails.

While non-market values may exist for many of the Francis Marion National Forest's natural resources, it can be very difficult to quantify use and non-use values. Since the methodologies for measuring these values can be controversial and difficult to apply, non-market goods tend to be undervalued. While it is not feasible to estimate non-market values during the planning process, it is important for Forest management to recognize that the true value of Forest resources include both market and non-market values so that they can make more informed decisions regarding their use. Many of these non-market values are discussed in other resource sections of the assessment and in section 7.1.1.2 "Benefits People Obtain from the National Forest System Plan Area."

6.1.1.4 Sustainability

National forests are productive assets which contribute to sustaining the viability of national, regional, and local communities. Uses, products, services, and visitor opportunities supported by national forest system lands produce a steady flow of benefits which contribute to the robustness and sustainability of local communities. While robustness implies diversity, sustainability refers to the community's capacity to maintain a certain level of function within the social, ecological, and economic systems it encompasses. Sustainability is a complex idea focused around intergenerational equity. This concept relates to the maintenance and enhancement of resources in order to meet the needs of current and future generations. The three components of sustainability are (Gilbert et al. 1996):

- *Environmental sustainability* – requires natural capital to remain intact so that natural systems can continue to complete the ecological processes essential to life.

- *Social sustainability* – requires the cohesive nature of society to remain intact so that people can continue to work towards common goals.
- *Economic sustainability* – occurs when development, that moves towards social and environmental sustainability, is financially feasible.

Sustainability is difficult to measure since the concept lacks a universally agreed-upon definition. The most widely accepted definition of sustainability was developed by the United Nation's Brundtland Commission and has since been incorporated into the Code of Federal Regulations (CFR), where sustainability is defined as the capability to meet the needs of the present generation without compromising the ability of future generations to meet their needs (36 CFR 219.19). As mentioned above, national forests are managed in compliance with the Multiple-Use Sustained-Yield Act so that their renewable resources are managed for the long-term social and economic benefit of human communities. By managing the uses, products, services, and visitor opportunities of national forests for their long-term viability, forest management fosters the social and economic ties between people and forest landscapes which create more resilient communities.

Economic Sustainability

The long-term livability of communities is closely related to the health of the local economy. Communities that bolster vital economies provide greater opportunities for income, employment, and leisure. These opportunities increase the attractiveness to live and work within the area, and help communities retain and attract local residents. Economic sustainability refers to the capability of society to produce and consume or otherwise benefit from goods and services, including contributions to jobs and market and nonmarket benefits (36 CFR 219.19). Forests contribute to local economic sustainability through the income, employment, and leisure derived from forest resources. As discussed above in the "Forest Contributions" section, the natural resources of the Francis Marion support approximately 147 local jobs and more than $5.1 million in labor income within the eight-county economy on an annual average basis (IMPLAN 2011). These contributions to local employment and labor income are derived from the Forest products and recreational opportunities provided by the Francis Marion.

Jobs and income provide a useful metric by which local economic activity supported by forests can be measured. Table 6-15 shows the Francis Marion's contributions to income and employment relative to total income and employment in the eight-county analysis area. Because of the large size of the analysis area, contributions from the Forest appear relatively small in the regional economy as a whole. The large and diverse economy of Charleston County, South Carolina, tends to dilute the effects of locally important industries. The Francis Marion National Forest's contribution to small rural communities in the analysis area would certainly be larger. Because it is not possible to attribute Forest outputs to each county, it is not possible to analyze the county-by-county or an individual community's contributions to employment and labor income.

The Francis Marion contributes to the economic sustainability of forest-dependent communities by cultivating a robust tourism and recreation industry and by continuing to support economic activity in local logging and wood manufacturing industries. Understanding how these forest-related industries benefit from the Francis Marion National Forest's resources is essential to understanding the consequences of changes in forest management. As part of the assessment process Forest specialists identified how the Forest's multiple uses (timber, watershed, fish and wildlife, and outdoor recreation), infrastructure, and cultural and historic resources contribute to the viability of the local economy.

Table 6-15. Forest contributions to local employment and income

	Employment (jobs)		Labor Income (thousands of 2011 dollars)	
Industry	**Area Totals**	**FMNF-Related**	**Area Totals**	**FMNF-Related**
Agriculture	7,923	7	$192,596	$296
Mining	654	0	$103,313	$6
Utilities	1,691	0	$148,344	$39
Construction	30,595	2	$1,481,650	$97
Manufacturing	34,521	8	$2,420,460	$663
Wholesale Trade	13,081	5	$754,017	$289
Transportation & Warehousing	18,534	5	$841,091	$200
Retail Trade	75,128	24	$2,253,189	$674
Information	8,342	1	$476,591	$68
Finance & Insurance	27,057	3	$1,230,943	$146
Real Estate & Rental & Leasing	38,344	5	$564,579	$66
Professional, Scientific, & Technical Services	36,098	4	$2,259,816	$233
Management of Companies	2,945	1	$204,845	$45
Administration, Waste Management & Remediation Services	42,669	7	$1,238,746	$181
Educational Services	7,747	1	$245,021	$21
Health Care & Social Assistance	49,948	5	$2,655,622	$239
Arts, Entertainment, and Recreation	20,142	19	$367,584	$428
Accommodation & Food Services	70,712	41	$1,637,333	$870
Other Services	30,718	4	$1,105,298	$147
Government	103,034	6	$7,853,719	$439
Total FMNF Contributions	619,882	147	28,034,757	5,147
Contributions as Percent of Total		0.02%		0.02%

Source: IMPLAN (2011).

Timber. As discussed in section 8 "Multiple Uses" and above in the "Forest Contributions" section, the timber industry has been an important part South Carolina's economy for centuries and is anticipated to continue to play a major role in the Lowcountry's economy well into the foreseeable future. Economic benefits realized by the analysis area from the Forest's timber resources include: (1) Forest revenue generated from timber sales[5], (2) profits to businesses from the sale of wood products, (3) wages for those working in the wood and wood products industry, (4) sales income of other dependent industries, and (5) local tax revenue from levies on forestry-related goods and services. In addition to economic benefits of timber harvesting, local communities receive economic benefits from leaving national forests' timber resources intact. Intact timber stands are a valuable forest resource since timber values increase with maturity and when made accessible to visitors, mature timber stands support recreational, spiritual, and cultural activities which contribute attracts tourists and outdoor enthusiasts to area.

[5] Although all revenue from timber sales on the Francis Marion are collected by the Federal government, a portion of revenues generated from Forest uses is distributed back to the counties of production. In this manner Berkley and Charleston counties receive revenue from timber sales on national forest land.

Harvesting the Francis Marion's timber resources also serves valuable function in helping to achieve desired conditions, maintaining or restoring key ecosystem characteristics, and improves forests' resistance and resilience to stressors. Ecologists have found that ecosystem resiliency is strongly correlated with ecological diversity. Social scientists have adapted these findings to develop the premise that more diverse communities generally adapt to and integrate change more rapidly and successfully than their less diverse counterparts. Community or socioeconomic resiliency relates to humans' ability to adapt to social and economic changes. Beckley et al. (2002) define community resiliency as: "the capacity of humans to change their behavior, redefine economic relationships, and alter social institutions so that economic viability is maintained and social stresses are minimized." If managing timber resources for ecosystem health does in fact increase human's ability to adapt to changes in their social and economic environment, then timber management on the Francis Marion can be attributed with increasing the resiliency of local communities.

Outdoor Recreation. Tourism is the largest economic activity associated with natural settings in the planning area. As discussed in section 8, "Multiple Uses", section 9 "Assessing Recreation Settings, Opportunities, Access and Scenic Character", and in the previous "Forest Contributions" section, many individuals rely on the Francis Marion to provide opportunities for a wide range of recreational activities. Trends presented in the "Social and Economic Existing Conditions" section suggest that the economic base of many nearby communities is shifting towards service and experience businesses that rely on outdoor recreation for their customers and as quality of life attractions for employees.

As discussed above in the "Forest Contributions" section, recreational experiences supported by the Francis Marion's natural, cultural, and historic resources are unique and are attributed with stimulating economic activity in services-related sectors that support the local tourism and recreation industry. In total, spending by recreationists on the Forest supports approximately 103 local jobs and nearly $3.1 million in labor income on annual average in the eight counties surrounding the National Forest (IMPLAN 2011). Economic activity stimulated by recreation on the Francis Marion National Forest also contributes to long-term viability of the local economy by attracting new money (money earned outside the local economy) into communities surrounding the Forest. The injection of non-local dollars through purchases of gas, food, lodging, and concessions prevents the local economy from becoming stagnant and generates opportunities for employment and income which may not exist in the local economy otherwise. Expenditures by non-local Forest visitors support approximately 42 jobs and $1.2 million in labor income within the eight-counties surrounding the Francis Marion on annual average (IMPLAN 2011).

Fish and Wildlife. Fishing, hunting, and wildlife watching significantly contribute to South Carolina's economy and continue to be extremely important economic driver in rural communities. Combined, it is estimated that the total economic impact of fishing, hunting, and wildlife viewing in South Carolina is over $3,794,000,000 per year, and these activities are directly attributed with supporting more than 44,600 jobs across the State (South Carolina Department of Vocational Rehabilitation 2009). While opportunities to participate in fishing, hunting, and wildlife viewing exist across the State, those provided by the Francis Marion National Forest are considered to be exceptionally unique opportunities.

The Francis Marion is one of the most biologically and ecologically diverse forest landscapes in the Southeast region. As discussed in section 8 "Multiple Uses", the diverse natural landscapes of the Forest provide habitat for many native and endangered species of fish and wildlife and is

designated as an "important bird area" by both the National Audubon Society and the American Bird Conservancy. Wildlife-related activities on the Francis Marion National Forest are an important attraction which draws visitors to the region, and the fish and wildlife managed by the National Forest are inputs in the production of wildlife-related experiences. According to 2011 NVUM data, wildlife-related activities accounted for approximately 21 percent of all Forest visits each year. As shown by Table 6-13, nearly 26 percent of Forest visitors are estimated to participate in wildlife viewing, 23 percent participate in hunting, and 8 percent fished while recreating on the Francis Marion National Forest. NVUM data also indicated that hunting and fishing are two of the most popular recreational activities pursued on the Francis Marion National Forest, and were reported to be the primary purpose of 21 percent and 5 percent of annual Forest visits, respectively.

The tourism and recreation industry has become an increasingly more important sector within the Francis Marion National Forest's analysis area. As discussed above in the "Forest Contributions" section, visitors traveling to the Forest to recreate often eat in local restaurants, shop in local retailers, and purchase gas and lodging. Spending by Forest visitors is attributed with supporting jobs and income in gateway communities which surround the National Forest. In total spending by recreationists on the Forest supports approximately 103 local jobs and nearly $3.1 million in labor income in the eight counties surrounding the National Forest. Since many Forest visitors travel to the Francis Marion National Forest specifically to participate in wildlife-related activities, fish and wildlife populations managed by the Forest are responsible for supporting a considerable share of Forest visits and local recreation-related spending each year. By managing healthy fish and wildlife populations forest management increases the Forest's ability to provide quality recreational experiences and contributes to economic sustainability by supporting a share of employment and income in the local tourism and recreation industry.

Watershed. South Carolina benefits from an abundant supply of water in the form of lakes, streams, rivers, wetlands and aquifers and the State's water resources remain relatively clean (SCORP 2008). As described in section 8 "Multiple Uses" the water resources of the Francis Marion and the surrounding Lowcountry have played an important role in the history and development of the region and continue to provide consumptive and non-consumptive uses which contribute to the vitality and livability of local communities. Francis Marion National Forest's watershed provides habitat to indigenous populations of shellfish, fish and wildlife and supports recreational experiences on the Forest. The diverse network of waterways which connects slow moving blackwater creeks to the Atlantic Intracoastal Waterway provides visitors with access to water for boating, fishing, hunting, visual aesthetics, and desirable locations for picnicking and camping.

By managing the Francis Marion's water resources to maintain the ecological integrity of the watershed, forest management promotes healthy fish and wildlife populations which contribute to local economic sustainability through Forest recreation as discussed in the above "Fish and Wildlife" section. In addition to the economic contributions supported by wildlife-related recreation, adaptive management to maintain the quality and quantity of Forest water resources further contributes local tourism and recreation by providing opportunities for high quality non-motorized and motorized water recreation. According to 2011 NVUM data, approximately 9 percent of Forest visitors participate in water activities while recreating on the Francis Marion National Forest each year. Although the Forest supports motorized water activities, the Francis Marion National Forest's waterways and wetlands are more heavily used by non-motorized water recreationists. NVUM estimated that 8 percent of Forest visitors participated in non-motorized water recreation and that these activities were reported to be the primary purpose of

nearly 7 percent of Forest visits each year. By supporting these opportunities for unique water-based recreation on the Francis Marion National Forest, the Forest's water resources further contribute to local economic sustainability by attracting kayakers, canoers, boaters, and swimmers to the Forest.

Renewable and Nonrenewable Energy and Mineral Resources. Although there are no mineral or nonrenewable energy operations operating on the Forest at this time, there is the potential to develop mining of limestone or sand on the Francis Marion National Forest and Forest management is exploring opportunities to provide logging debris for gasification. While renewable and nonrenewable energy and mineral resources on the Forest do not currently contribute to local economic sustainability, technological advances and changes in lease stipulations could increase the exploration, development, and extraction of Forest resources in the future. Future development of Forest's energy and mineral resources would stimulate economic activity in the agricultural and mining sectors and increase local employment and income in these sectors. In this manner, the Francis Marion's renewable and nonrenewable energy and mineral resources have the potential to contribute to local economic sustainability in the future.

Designated Areas. The Francis Marion manages a number of administratively designated recreation and interpretative areas which serve as a gateway to the Forest's natural landscape (Table 6-16). These sites support opportunities for Forest visitors to participate in recreational and educational activities and provide them with access to facilities designed to improve the quality of Forest experiences (see the below discussion on Forest infrastructure for further discussion of Forest facilities). While many visitors are attracted to the Francis Marion National Forest to participate in dispersed recreational activities, designated recreation and interpretative areas serve as the primary destination for the majority of Forest visitors. Special site designations increase awareness of recreational and educational opportunities on the Forest which translates to increased tourism and local recreation-related spending. By increasing recreational use the designated recreation and interpretative areas of the Francis Marion increase employment and income stemming of the region's robust tourism and recreation sector and contributes the sustainability of the local economy.

Table 6-16. Designated areas and recreational uses

Area	Primary Uses
Recreation Areas	
Buckhall Recreation Area	Camping, RV camping, fishing, picnicking, motorized and non-motorized water activities
Elmwood Campground	Camping, big game hunting
Honey Hill Campground	Camping, picnicking
Halfway Creek Trail Campground	Camping, hiking, mountain biking
Twin Ponds Rifle Range	Target shooting
Boggy Head Rifle Range	Target shooting
Huger Recreation Area	Fishing, picnicking, non-motorized water activities
Interpretative Areas	
Sewee Visitor and Environmental Education Center	Visitor center, interpretive programming loop trail, fishing
Sewee Shell Ring Interpretive Trail	Outdoor learning, viewing scenery
Battery Warren	Trail, interpretive information
I'on Swamp Interpretive Trail	Outdoor learning, hiking, wildlife viewing

Infrastructure. As discussed in section 11 Forest infrastructure helps support the mission of the Forest and increases the ability for Forest users to access and enjoy the Francis Marion National Forest. Over the years Forest management has invested millions to construct and maintain roads, trails, and facilities which improve the quality of visitor experiences. In addition to the extensive network of roads and trails which provide visitors with access to the Forest's stunning landscapes, the Francis Marion National Forest provides facilities at a number of developed and dispersed recreation and interpretative areas (Table 6-17).

Table 6-17. Recreation sites and their facilities

Sites	Facilities
Recreation Areas	
Buckhall Recreation Area	Camping with electric hookups, picnic, boat ramp, fishing pier, trailhead
Elmwood Campground	Camping, vault toilet, game check station
Honey Hill Campground	Camping, vault toilet
Halfway Creek Trail Campground	Camping
Twin Ponds Rifle Range	Covered shooting benches
Boggy Head Rifle Range	Covered shooting benches
Huger Recreation Area	Picnic, vault toilet, boat ramp
Interpretative Areas	
Sewee Visitor and Environmental Education Center	Visitor center, interpretive programming loop trail, fishing
Sewee Shell Ring Interpretive Trail	Boardwalks, interpretive information
Battery Warren	Trail, interpretive information
I'on Swamp Interpretive Trail	Trail, interpretive information

Investment in infrastructure has significantly increased the public's access to the Francis Marion National Forest's natural landscape and has enabled the Forest to support a greater number of

unique recreational and interpretive experiences to the public. These investments in Forest infrastructure can be attributed with not only increasing the quality of recreational and educational experiences on the Forest, but also with increasing the carrying capacity of developed and dispersed recreation sites. Although budget deficits have created a backlog of maintenance needs for existing facilities, trails, and roads, Forest infrastructure continues to contribute to the vitality of local economies by facilitating quality recreational and educational experiences attributed with attracting visitors to the Francis Marion National Forest. For further details on the contributions of recreational and educational Forest visits to local economic sustainability refer to the previous "Outdoor Recreation" section and the following "Cultural and Historic Resources" section.

Cultural and Historic Resources. As discussed in many of the sections describing Forest resources, the landscape of the Francis Marion National Forest has a rich history which dates back more than 15,000 years. Successive generations of native and early Americans have relied on the natural resources of the Francis Marion National Forest to foster social, economic, and spiritual growth and traces of past Forest users and uses remain scattered across the modern Forest landscape. As of today more than 4,000 archaeological sites, 4 historic buildings, and 2 historic fire lookout towers have been discovered on the Francis Marion National Forest. In addition to known sites with cultural and historic significance the potential to find additional resources which contribute to the knowledge of past human activities on the Forest remains high. The Francis Marion National Forest's cultural and historic resources are managed under several Federal statutes including: the Antiquities Act of 1906, the Wilderness Act of 1964, the National Historic Preservation Act of 1966 (NHPA), the National Forest Management Act of 1976 (NFMA), and the Archaeological Resources Protection Act of 1979. Heritage management on the Francis Marion National Forest seeks to locate, identify, and protect sites where artifacts of early human occupation have been found to increase the knowledge and appreciation for the unique heritage and natural history of South Carolina's lowcountry.

With the exception of interpretive areas occurring in major recreation areas, the Forest Service does not publicize the exact locations of culturally and historically significant resources to protect the integrity of Forest heritage sites. Table 6-18 lists the designated interpretative areas managed by the Francis Marion National Forest and the reason for their cultural and historic significance. These developed heritage sites promote local heritage tourism which enables the public to enjoy our Nation's heritage through greater knowledge and appreciation of local Forest history. Heritage tourism and educational experiences on the Francis Marion National Forest have been identified as an underutilized Forest resource. Although NVUM data indicates that nearly 3 percent of Forest visitors visit historic sites while recreating on the Francis Marion, historical sites were reported to be the primary reason for less than 0.01 percent of Forest visits. This indicates that Forest's cultural and historic resources contribute slightly towards local economic sustainability by supporting unique visitor experiences on the Francis Marion, and suggests that further development of the Forest's heritage programs may increase the demand for interpretative experiences which could increase future employment and income contributions associated with local heritage tourism.

Table 6-18. Designated interpretative areas for the Francis Marion's heritage resources

Interpretative Areas	Cultural & Historic Significance
Sewee Visitor and Environment Education Center	Jointly operated by the Forest Service and the U.S. Fish and Wildlife Service, this 9,000-square-foot facility features hands-on interpretive displays exploring the heritage and natural history of the area.
Sewee Shell Interpretive Trail	The Sewee Shell Ring is the northernmost prehistoric coastal shell mound along the Florida, Georgia, and South Carolina coasts. Today the shell ring serves as a monument to prehistoric Native American culture and provides five interpretive sites along the scenic trail.
Battery Warren	Named after Colonel Samuel Warren, the local Revolutionary War hero who previously owned the land, the Battery served as an earthen gunning fort built to blockade Union forces from moving up the Santee River during the Civil War.
I'on Swamp Interpretive Trail	This interpretive loop follows the remnants the elaborate grid of canals and dikes to remnants of the 200-year-old Witheywood Planation which was once part of the State's lucrative "Carolina Gold" rice trade. Interpretive sites along the trail provides information on the agricultural history of the region and how slaves brought over from Africa contributed to success of southern plantations.

Social Sustainability

Sustainable communities fulfill both the material and immaterial needs of their residents. While local economic conditions can be used as an indicator of material needs, immaterial needs are better reflected in the values (i.e., conceptions of what is good or bad, right or wrong, desirable or undesirable), beliefs (i.e., judgments about what is true or false), and attitudes (i.e., tendencies to react favorably or unfavorably to a situation, individual, object, or concept) of people (Allen et al. 2009). These immaterial needs are associated with the relationships, heritage, societal values, and institutions which enable people to share experiences. Shared social, cultural, and historic experiences cultivate a sense of community that connects people to one another and cause individuals to ascribe a deeper meaning to the place where they live (Eisenhauer et al. 2000). "The social, cultural, and emotional attachments people form to certain places are indicative of local quality of life and provide the foundation on which a sense of community is built. Sense of community is a feeling members have of belonging, a feeling that members matter to one another and the group, and a shared faith that each member's needs will be met through their commitment to be together" (McMillan and Chavis 1986).

The long-term viability of communities is largely dependent upon the social, cultural, and emotional attachments members forge to people and places. Although communities are often thought of in terms of geographical boundaries, communities within the Francis Marion's eight-county study area can be described by their physical place and by their connections to the local landscape. This distinction is best characterized as the difference between communities of place (i.e., people who are bound together because of where they reside, work, visit or otherwise spend a continuous portion of their time) and communities of interest (i.e., people who share a common interest or passion, regardless of their location or degree of interaction) (Patterson et al. 2003). The distinction between place and interest is not mutually exclusive; in fact many communities share location and values, beliefs, and attitudes because community members choose to live near like-minded people.

Uses, products, services, and visitor opportunities supported by National Forests produce a steady flow of benefits which contribute to the sustainability of Forest dependent communities. While contributions to communities of place can be measured in terms of the economic activity

Forest resources support in the local economy (discussed in the "Forest Users and Contributions" and the "Economic Sustainability" sections), the social and cultural links between the Forest and communities of interest often transcend the boundaries of a physical place. The Francis Marion contributes to the long-term vitality of communities of interest by supporting the shared traditions, culture, and activities of their members.

While each community of interest may have a unique character and unique priorities related to natural resource use, the Forest contributes to the liveliness of these communities by facilitating shared values, beliefs, and attitudes associated with the Forest's resources. In this manner, the Francis Marion contributes to the long-term sustainability of several communities of interest. Social sustainability refers to the maintenance of vibrant communities through the network of relationships, traditions, culture, and activities that connect people to each other and to the land (36 CFR 219.19). Preliminary discussions with the public and Forest specialists identified several communities of interest associated with the Francis Marion. These communities include people interested in recreation and Forest access, natural landscapes and development buffer areas, historic and cultural significance, and timber and wood products. Responses to a collaborative on-line tool known as "Crowdbrite" were collected at a public workshop and via the internet and provided valuable insight into what these communities believed, valued, and their attitudes towards the Francis Marion.

Communities Interested in Outdoor Recreation and Forest Access. Crowdbrite responses revealed that a large community of recreationists highly valued the Francis Marion because of the recreational experiences it supported. Members of the recreation community appreciated these Forest lands for providing opportunities for trail running, hiking, biking, canoeing and kayaking, camping, shooting, riding OHVs, birding, fishing, and hunting. Some recreationists had developed strong personal bonds with the Forest through years of participating in activities like hunting. Several comments highlighted that the Forest provided children with access to nature and that the recreational experiences it supported facilitated multi-generation Forest experiences where parents were given the opportunity to teach their children to appreciate and respect nature. The Francis Marion National Forest was also attributed with providing people with access to free forms of entertainment, like birding and various other types of wildlife viewing; access to these activities were attributed with increasing low-income residents' access to recreational experiences. Though conflicts arise over competing recreational uses, recreationists generally shared positive attitudes towards the Francis Marion and credited it as being as being an important recreational site in South Carolina's Lowcountry. By supporting unique recreational experiences the Francis Marion National Forest helps cultivate an appreciation for the outdoors that continues to be passed down to younger generations through recreational experiences thereby contributing to the longevity of recreational communities who use the Forest.

Communities Interested Natural Landscapes and Scenic Beauty. Public comments collected through Crowdbrite highlighted a large community of Forest stakeholders who shared a deep appreciation for the Forest's wild landscape and scenic beauty. These Forest stakeholders take great pleasure in using the Francis Marion as a refuge away from the people, noise, and pollution of cities, and credit the scenic, undeveloped landscapes of the Forest with improving their quality of life. The nature enthusiast community attributes the Francis Marion National Forest with contributing to the overall beauty of South Carolina's Lowcountry and valued its scenic resources for cultivating mental clarity and spiritual renewal. People associated with this community of interest escape to the Francis Marion because the exploration and quiet enjoyment of its diverse landscapes provides relief from the stress of their daily lives and promotes self-

reflection and inner peace. Community members who live in cities believed that the Forest's natural beauty served as a reminder of the importance of incorporating nature in to their lives and enabled them to reconnect with a rural lifestyle. Even when unable to travel to the Forest, some nature enthusiasts find inner peace in knowing that these undeveloped lands are protected. The Francis Marion contributes to the longevity of nature loving communities by managing the Forest to protect the integrity of its visual resources so that it can continue to promote the mental, physical, and spiritual health of current and future generations.

Communities Interested in Wildlife. The Francis Marion is highly valued by a large community interested in natural plant and animal communities. Comments collected via Crowdbrite indicated that the Francis Marion National Forest was significant to them because it provided critical habitat to a wide range of terrestrial, aquatic, and avian wildlife. These stakeholders believe that management of the Francis Marion can be credited with protecting and enhancing habitat which is important to native and migratory wildlife. They consider the conservation of these lands to be extremely important to endangered species, neotropical migratory birds along the Atlantic Flyway, and to various populations displaced by extensive urban development in physical communities surrounding the Francis Marion National Forest. While public comments suggested that community members may derive pleasure from knowing habitat provided by the Francis Marion National Forest contributes to sustaining healthy animal and bird populations, most the value reflected in responses from these community members was derived from birding experiences on the Forest. Although wildlife enthusiasts are attracted to the Forest because it provides the opportunity to observe a wide variety of wildlife in a single visit, the Francis Marion National Forest is world renowned for the unique bird watching experiences. Several responses indicated that the Francis Marion was the only place to provide birders with an opportunity to see red-cockaded woodpeckers or Bachman's warblers in their natural habitat, making the Francis Marion extremely important to birding communities. By managing the Forest to protect and enhance wildlife habitats, the Francis Marion National Forest contributes to sustaining communities interested in wildlife by providing current generations with opportunities to view and learn about the region's native wildlife so they can pass knowledge down to future generations.

Communities Interested in Historic and Cultural Significance. Although the physical landscape of the Francis Marion has changed over time, the Forest's uplands, swamps, and marshes still holds "memories" of its past prehistoric, colonial, and military significance. Today the Francis Marion National Forest serves as a reminder of the collective and individual roots of many Americans. The historic features which hold these memories possess heritage values which help people form attachments to places and provide an understanding of their place in the natural and cultural environment. Comments solicited through Crowdbrite highlighted the Forest's importance to the culture and heritage of a large share of Forest stakeholders. The Forest is generally perceived as an important part of the cultural and heritage of the Lowcountry and attributed with protecting a number of historical sites. Many stakeholders believe that Forest management of these sites increases public awareness of and access to opportunities to learn and interpret their cultural and historic significance. By preserving and facilitating the interpretation of these resources the Francis Marion National Forest ensures that the cultural legacy and heritage values of the Francis Marion's lands will be passed on to present and future generations.

Although comments received through Crowdbrite did not mention which cultures the Forest contributed to, the Francis Marion National Forest is located almost entirely within a federally recognized heritage area known as the Gullah Geechee Corridor. This corridor was established in 2006 to protect and enhance resources associated with the Gullah Geechee people. The Gullah

Geechee are American descendants of enslaved immigrants brought over primarily from coastal West Africa. Years of captivity and relative isolation enabled various West African traditions, skills, and languages to fuse together, giving rise to the unique culture which has been passed down for generations. An inventory of the Corridor's historical, cultural, and natural resources, identified three Forest-dependent communities as having cultural landscapes[6] and ethnographic resources[7] that increase the awareness and understanding of the culture and history of the Gullah Geechee people (Gullah Geechee Cultural Heritage Corridor Commission 2012). Located entirely within the Francis Marion, the communities of Awendaw, Huger, and McClellanville are recognized for helping the Gullah Geechee share their heritage by supporting six primary interpretive themes: origins and early development; the quest for freedom, equality, education, and recognition; global connections; connection with the land; cultural and spiritual expression; and Gullah Geechee language. Since the natural and cultural landscapes of these communities are synonymous with those of the Forest, the management of Forest resources for long-term sustainability inherently contributes to the long-term viability of surrounding communities and to unique cultures of the people living within them.

Communities Interested in Timber and Wood Products. The lands which are now managed by the Forest Service as the Francis Marion National Forest have a long history with the Timber industry. Although historic harvests far exceeded those in recent years, modern timber management enables the Forest to provide a steady and reliable supply of forest products which contribute to sustaining communities interested in timber and wood products. Responses collected through Crowdbrite indicated that community members generally view the timber harvesting in a positive light, but believe that the extraction of timber-related goods needs to be done in ways which minimize adverse impacts to habitat and recreation. Recent restoration projects have provided timber and wood products for personal and commercial use and have been attributed with improving the health and function of the Francis Marion's diverse forest ecosystems. Although not all individuals interested in timber-related Forest products are in agreement over what the Forest's annual yield should be, Crowdbrite responses indicated that there is a general consensus that the Francis Marion needs to continue to improve its timber management to ensure future Forest users can rely on the these lands to provide Forest products for personal and commercial use. By managing timber resources to improve stand health and ensure reliable future yields, the Francis Marion contributes to the continued viability of communities of interested or dependent upon timber and forest products.

[6] Cultural Landscapes are areas that reflect how people adapt and use natural resources, as expressed by the land organization or use, settlement patterns, circulation, or types of structures, and how the area reflects cultural values and traditions. The National Park Service categorizes cultural landscapes into four types: historic designed landscapes, historic vernacular landscapes, historic sites, and ethnographic landscapes. Cultural landscapes associated with the Gullah Geechee corridor may not be previously identified as "cultural landscapes," but can include sites that fulfill the above definition of a cultural landscape. Examples might include plantations, village sites, or other important places with ties to long-established groups identified with Gullah Geechee cultural history.

[7] Ethnographic resources are any site, structure, object, landscape, or natural resource feature assigned traditional legendary, religious, subsistence, or other significance in the cultural system of a group traditionally associated with it. These resources generally relate to folklife, religious traditions, foodways, anthropology, ethnomusicology, or the humanities.

7 Ecosystem Services: Assessment of Benefits

7.1.1.1 Preliminary Findings

1. The Francis Marion provides a wide range of goods and services essential to sustaining life and fulfilling basic human needs and desires. Vital ecosystem services provided by the Forest include clean water and air, natural fibers and wood products, the regulation of natural hazards, and recreational opportunities. In addition to sustaining and improving the quality of life within the Forest's ecoregion, ecosystem services provided by the Francis Marion feed in to larger hydrological, biogeochemical, and carbon cycles which moderate natural phenomena at a global scale.
2. Although continued population growth in the Charleston area has placed additional demand on natural landscapes to provide ecosystem services, various sections of this assessment have identified an array of system drivers which can adversely affect the Forest's ability to provide these life sustaining services. As the region's natural landscape grows increasingly more fragmented and degraded, the provision of ecosystem services by the Francis Marion National Forest will play an even larger role in moderating natural phenomena and sustaining quality of life locally and across the globe.

7.1.1.2 Benefits People Obtain from the National Forest System Plan Area

National forests are productive assets which produce a steady flow of benefits in the form of ecosystem services. Ecosystem services are "components of nature, directly enjoyed, consumed, or used to yield human well-being" (Boyd and Banzhaf 2007). Healthy forests provide an abundance of ecosystem services, including clean water and air, biodiversity and forest products. The United Nations-sponsored Millennium Ecosystem Assessment identified four major categories of ecosystem services: provisioning, regulating, cultural and supporting services. The following key services were identified to be contributed by the Francis Marion National Forest through specialized scoping (other services, including outdoor recreation, range, timber, watershed, and fish and wildlife, are discussed in the "Assessing Multiple Use" section):

- Provisioning Services
  - Natural Fibers
  - Food Production
- Regulating Services
  - Purification of Water and Air
  - Carbon Sequestration
  - Pollination
  - Natural Hazard Regulation
- Cultural Services
  - Cultural and Heritage Values
  - Spiritual, Inspirational, and Aesthetic Services
- Supporting Services

- Nutrient Cycling

Provisioning Services

Provisioning services are environmental goods which are extracted from ecosystems for human benefit. Initial scoping identified two key provisioning services provided by the Francis Marion National Forest, food production and natural fibers. The provision of these Forest products contributes to the well-being of communities surrounding the Forest.

Natural Fibers. The larger Francis Marion ecoregion is made up of several distinct ecosystems, including upland forests, wetlands, and brackish marshes. There are approximately 1,600 documented species of plants growing within the National Forest, including 32 species of orchids, 22 species of ferns, and 12 species of carnivorous plants. Natural fibers grown on the Forest provide numerous benefits. Pine needles, or straw, drop from the longleaf and loblolly pines on the Francis Marion throughout the year. These fibers provide habitat and forage for wildlife, reduce the erosion and loss of topsoil, and improve soil tilth and decomposition. Straw coverage on the forest floor is also very important for the survival and growth of plants because it contains important nutrients like nitrogen, phosphorus, calcium, and magnesium that return to the soil as the straw breaks down. Partially decayed pine straw also helps lock in moisture and insulates soil from temperature extremes.

Although significant demand for pine straw has been shown by local landscapers and Gullah-Geechee[8] basket weavers, over harvesting pine straw is known to cause adverse effects to the ecological health and function of the Forest. Forest management has tried in the past to make pine straw a viable forest product on the Francis Marion National Forest, but issues with administering permits and the wide spread abuse of permits to harvest quickly grew to be a major problem. While straw is abundant in pine stands across the Forest, illegal raking and stressors and drivers of Longleaf and Loblolly Pine ecosystems threaten straw coverage on the Francis Marion. For a discussion of trends and system drivers see section 1 “Terrestrial Ecosystems.”

Food Production. The Francis Marion National Forest provides habitat for an abundance of aquatic and terrestrial life. Many of the species found on the Francis Marion are commonly hunted and fished. Commonly hunted species include: white-tailed deer, eastern wild turkey, woodcock, squirrel, opossum, fox, black bear, raccoon, rabbit, wild boar, waterfowl, morning dove, ruffed grouse and quail. Commonly fished species include: bass, bluegill, catfish, crappie and trout.

While the majority of hunters and anglers in the U.S. participate for sport, many individuals continue to hunt for subsistence. Subsistence hunting and fishing are important to the economies and cultures of families and communities in rural America. Those hunting and fishing for subsistence do so strictly to provide food for themselves and their families. Wild fish, game and non-game animals harvested from national forest system lands often supplement meager food

[8] Gullah Geechee (\ˈgə-lə\ \ˈgē-chē \)is a sovereign African-American nation whose boundaries stretch along the Atlantic coast Sea Islands and Lowcountry from Jacksonville, North Carolina, to Jacksonville, Florida. The Gullah people are direct descendants of Africans who were brought to the United States and enslaved for generations. Their culture is manifested in a system of practices/principles that emerge from: (1) their diverse African (primarily West Africa) origins, (2) the intense interaction among people from different language groups, and (3) generations of isolation in settings where enslaved Africans and their descendants were the majority population. Gullah-Geechee weave native pine straw and sweetgrass into coiled baskets that resemble those crafted by the Wolof people in Senegal.

dollars and accounts for a significant portion of the meat consumed by these households. In this manner the provisioning services of the Francis Marion National Forest provide local families and communities with a secondary income which may partially offset low wages and alleviate poverty in the rural areas surrounding the Francis Marion. For a discussion of current conditions of and trends in wildlife populations which support opportunities for subsistence hunting and fishing see information specific to hunting in section 9 and chapter 8.3 "Fish and Wildlife". For a discussion of stressors and drivers affecting wildlife on the Francis Marion National Forest see section 3 "System Drivers."

Regulating Services

Regulating services are the benefits provided by ecosystem processes that moderate natural phenomena. Initial scoping revealed that the Francis Marion provides a number of regulating services, including: purification of water and air, carbon sequestration, pollination, and natural hazard regulation. While these processes occur within the Forest's ecoregion, benefits from the Francis Marion National Forest's regulating services contribute to moderation of natural phenomena, including natural disasters, at a global scale.

Water Purification (filtration). Forests act as natural reservoirs, treatment plants, and stormwater management systems. Physical, chemical, and biological processes enable forest vegetation and soil to filter and absorb surfacewater, replenishing underground aquifers and moderating runoff during rainstorms. America's forests act as living filters, processing nearly two-thirds of the nation's water supply. In their natural and healthy state forests have been proven to be highly effective at removing metals, sediment, and excess nutrients. Research has shown that riparian areas can reduce nitrogen concentrations in runoff and floodwater by up to 90 percent and phosphate concentrations by 50 percent (Gilliam 1994) and that wetlands can remove between 70 and 90 percent of entering nitrogen and up to 80 percent of total phosphorus (Reilly 1991; Gilliam 1994; Peterjohn and Correll 1984; Richardson 1985; Gale et al. 1994; Walbridge and Struthers 1993).

Water filtration services provided by well-functioning ecosystems help maintain the integrity of the watersheds and provide local communities with clean drinking water and water suitable for industrial uses, recreation, and wildlife habitat. By filtering out pollutants upland forests, riparian areas, and wetlands help keep base loads within reasonable levels which reduce municipal water treatment costs and alleviates demand for costly infrastructure. It has been estimated that the nearby Congaree bottomland hardwood swamp removes roughly the same amount of pollutants each year as a $5 million water treatment plant (U.S. EPA 1993). By managing for the health of forest ecosystems the Francis Marion National Forest directly contributes to regional water quality and helps reduce financial costs associated with municipal water supplies. For information on baseline water quality see section 2.2.4 "Water Quality"; for information on stressors and drivers affecting the Forest's watershed see section 3 "System Drivers."

Air Purification. Air is essential to sustaining life and forests play an important role in replenishing and purifying the oxygen on Earth. Forest vegetation harnesses energy from the sun and converts carbon dioxide and water into sugars through photosynthesis. This conversion process provides plants with the essential building blocks needed to grow leaves, flowers, fruits, and seeds, and causes plants to release clean air into the atmosphere as a byproduct. On average, a healthy, mature tree produces 260 pounds of oxygen per year. With the average person consuming 386 pounds of oxygen a year it takes approximately 1.5 mature trees to support one person for a year.

Forests filter out a number of air pollutants and toxic gases which have been associated with adverse health and environmental effects, such as respiratory infections and acid rain. Leaves act as highly effective filters, capable of capturing fine particulates less than 10 microns in size. In addition to filtering particulates and absorbing carbon dioxide, forest vegetation can reduce ground-level ozone, carbon monoxide, nitrogen oxides, sulfur dioxide, and lead. Research has shown trees significantly improve air quality. Tree cover in a 212 hectare urban park was found to be capable of removing 48 pounds of particulates, 9 pounds of nitrogen dioxide, 6 pounds of sulfur dioxide, 2 pounds of carbon and 100 pounds of carbon a day. One 12-inch-diameter sugar maple can remove 60 milligrams cadmium, 140 milligrams of chromium, 820 milligrams of nickel and 5,200 milligrams of lead in a single growing season (Coder 1996). Large trees are capable of absorbing 10 pounds of air pollution a year, including 4 pounds of ozone and 3 pounds of particulates.

By maintaining the Forest's wildlands in their natural state the Francis Marion National Forest acts as a large filter for the region's airshed, absorbing thousands of pounds of air pollution each year. The Forest can be directly attributed with improving regional air quality and mitigating the adverse effects on human and natural systems. The Francis Marion's role in maintaining regional air quality has become increasingly important as rapid development in the Charleston area continues to contribute to diminishing regional air quality. For information on current air quality conditions and stressors affecting the airshed see sections 2.2.2 and 3.4.

Carbon Sequestration. Carbon dioxide is a naturally occurring greenhouse gas which is recycled through a complex set of natural processes which continuously create and use carbon dioxide. Carbon sequestration is the process by which trees, grasses, and other plants absorb atmospheric carbon dioxide through photosynthesis, "locking" carbon dioxide in biomass and soils for long-term storage. Trees act as reservoirs holding sequestered carbon in trunks, branches, foliage, and roots, slowly releasing its carbon stock through the decaying process at the end of its life cycle or permanently storing carbon in the durable goods created from timber products. Young trees are capable of absorbing carbon dioxide at a rate of 13 pounds per tree annually, with 1 acre of young forest sequestering nearly 2.5 tons of carbon on annual average. Although trees become most effective at sequestration after about 10 years, increasing carbon dioxide absorption from 13 pounds to 48 pounds per year, carbon uptake in mature forests is balanced by carbon released from decaying vegetation. The U.S. Forest Service estimated that forests in the United States captured a combined total of 309 million tons of carbon annually between 1952 and 1992 (USDA Forest Service Pamphlet #R1-92-100).

The movement of carbon in and out of Forest's trees and soils is part of the Earth's global carbon cycle. While carbon dioxide is naturally consumed and released by healthy ecosystems, human activity significantly contributes to carbon dioxide emissions. Carbon dioxide is a byproduct of nearly all human activity, including breathing, driving cars, turning on a light, and by heating or cooling our homes. Natural carbon sequestration helps offset carbon emissions associated with human activities, including deforestation, forest fires, and the extraction and burning of fossil fuels. Forests store large amounts of carbon play an active role in mitigating the carbon footprint of human activity. Between 1952 and 1992 sequestration by U.S. forests offset nearly 25 percent of manmade carbon emissions (USDA Forest Service Pamphlet #R1-92-100), and carbon removed from the atmosphere by forest growth or stored in harvested wood products offset 12 to 19 percent of U.S. fossil fuel emissions (Ryan et al. 2010).

Forest carbon stocks fluctuate over time as the forest grows and recovers from varying levels of natural and human disturbances. Although the Francis Marion National Forest was a source of

atmospheric carbon for a short period after Hurricane Hugo, the Francis Marion National Forest generally serves as a large carbon sink. For decades prior to, and over the most recent two decades since Hurricane Hugo, Forest growth has enabled the Francis Marion National Forest to sequester large amounts of carbon. Recent inventories indicate that the Francis Marion National Forest serves as one coastal South Carolina's largest carbon sinks, accumulating 14 percent of carbon over a 5-year period. Although the Francis Marion National Forest captures and stores carbon dioxide within the Forest's airshed, sequestration by the Francis Marion is part of a larger global recycling process known as the carbon cycle, which helps lower global stocks of greenhouse gases. For a detailed discussion of trends and drivers affecting carbon stocks see section 4 "Carbon Assessment."

Pollination. Pollination is the fertilization of flowering plants through the transfer of pollen from the male part of the flower to the ovaries of the same species. Although some plant species are able to pollinate themselves, or may be pollinated by the wind, the vast majority of flowering plants need pollinators to help move pollen from the male to female parts of the plant. Pollinators come in many forms and include a number of invertebrate and vertebrate species which can be found on the Francis Marion National Forest. The Francis Marion is home to a large number of the region's pollinators since it provides ideal nesting grounds and food supplies for a variety of species. Pollinators commonly seen on the Forest include: bees, moths, butterflies, birds, deer, bears, rabbits and rodents. Since these national forest system lands account for a significant share of wildland habitat in the region, the Francis Marion plays a critical role in maintaining regional biodiversity by ensuring the production of seeds required to maintain natural plant communities.

Natural Hazard Regulation. Some natural processes can be destructive to human and natural systems initially, but beneficial to ecosystems over the long run. These processes are known as natural hazards and may include floods, fires, and other natural events with the potential to cause harm. The severity of hazardous events can vary from nuisance to catastrophic, where extreme events cause such devastation that their aftermath is better known as a natural disaster. The degree to which people are exposed to these hazards, the magnitude of hazardous events and communities' ability to cope with and recover from their occurrence is largely dependent upon the condition of the surrounding ecosystem.

Hazardous events shape the physical landscape of U.S. forests and contribute to the overall health of these productive ecosystems. Healthy forests provide encroaching development with a physical buffer and facilitate a wide range of natural processes that moderate the intensity and frequency of extreme events. While natural hazards are often associated with injury, death, and damage to property in nearby communities, these events stimulate biodiversity and support ecological functions which reduce the risk of catastrophic disasters in the future. Like many forests, the Francis Marion is located is part of a larger fire-dependent ecosystem which contains numerous rivers and streams that are prone to flooding during severe weather events. Although wildfires and storm related flooding regularly threaten communities surrounding the Forest, the Francis Marion helps alleviate flooding by reducing run-off and moderating stream flows during heavy storms, prevents soil erosion than can cause slope instability and landslides, and reduces the likelihood of catastrophic wildfires by maintaining characteristic vegetation and fuel conditions consistent with the region's natural fire regime.

In their natural state, the Francis Marion National Forest's wildlands directly contributes to the region's resilience to hazardous events and greatly diminishes the risk of natural disasters affecting communities surrounding the Francis Marion. The Forest's ability to regulate and

mitigate risks of natural hazards is directly related to the health of Forest ecosystems. The degradation of natural systems greatly diminishes their ability to complete ecological functions that reduce the frequency and severity of natural disturbances. Changes in ecosystem function are caused by ecological drivers and stressors. Drivers are major environmental forces that have large scale influences on the natural system (e.g., climate, hydrology, and major natural disturbances); stressors, which are also drivers, are the human induced perturbations which have large or regional-scale influences on the natural system (e.g., water management, contaminants, exotic species) (Ogden et al. 2005). Section 3 discusses trends in natural disturbances, including wildfires and climate and weather events and the effects of natural disturbances on specific resources is discussed in chapters 1, 2, and 4.

Cultural Services

Cultural Services relate to the nonmaterial benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experiences (Millennium Ecosystem Assessment 2005). In relation to Forest ecosystems, these services are generally what people hold most dear and influence the way people view and value other goods and services provided by the Forest. Initial scoping identified that the Francis Marion supported a number of cultural services which benefited people, including: cultural and heritage and spiritual, inspirational, and aesthetic values.

Cultural and Heritage Value. While the physical and cultural landscape of the Francis Marion has evolved over time, past cultural ties have left a lasting impression on the Forest's uplands, swamps, and marshes. Located in South Carolina's Lowcountry region, the Francis Marion National Forest boasts a rich history which includes prehistoric, colonial, and military significance. First settled by prehistoric Native Americans, these lands were later occupied as early colonial settlements and plantations and played a role in both the Revolutionary and Civil wars. While present occupation of the Francis Marion is limited to a few small communities and inholdings, its landscape still holds "memories" of the past which serve as a reminder of the collective and individual roots of many Americans. The historic features which hold these memories possess heritage values which help people form attachments to places and provide an understanding of their place in the natural and cultural environment. These heritage values are a source of civic pride and contribute to the local sense of community.

The Francis Marion is located almost entirely in a nationally recognized heritage area which extends along the southeastern coast of the United States. Known as the Gullah Geechee Corridor this heritage area is home to one of the country's most unique cultures and languages. The Gullah Geechee culture is a byproduct of the retention and fusion of West African beliefs, traditions, and skills by enslaved black immigrants along the southeastern coast of the United States. The relative isolation of these people enabled the unique traditions, beliefs, and languages of West Africa's coastal rice-producing region to remain intact, allowing them to be passed down through generations. Modern descendants of these immigrants, known as the Gullah Geechee, continue to live and celebrate their rich African and American heritage in communities surrounding the Francis Marion National Forest.

According to a 2006 inventory of the Corridor's historical, cultural, and natural resources, three of the four towns located within the Francis Marion National Forest contained cultural landscapes and ethnographic resources that increased the understanding and awareness of Gullah Geechee people, culture, and history (Gullah Geechee Cultural Heritage Corridor Commission 2012). The Forest-dependent communities of Awendaw, Huger, and McClellanville were attributed with helping the Gullah tell their story by supporting six primary interpretive themes:

origins and early development; the quest for freedom, equality, education, and recognition; global connections; connection with the land; cultural and spiritual expression; and Gullah Geechee language.

Comments received during specialized scoping to identify ecosystem services indicated that Forest users believed the Francis Marion National Forest was an important part of the cultural heritage of the Lowcountry and that the public had attached cultural and heritage values to many of its sites. By preserving and facilitating the interpretation of these resources the Francis Marion National Forest ensures that the cultural legacy and heritage values of the Francis Marion's lands will be passed on to present and future generations. For a discussion of current conditions, trends and stressors affecting cultural and historical resources and uses see section 13.

Spiritual, Inspirational, and Aesthetic Services. For centuries humans have recognized that Forests possessed an intrinsic value which exceeded the benefits they received from consumptive uses. In addition to providing sustenance, Forest landscapes provide aesthetic enjoyment, artistic and spiritual inspiration, and emotional comfort. Although the modern world has become increasingly centered around cities, the mental, physical, and spiritual well-being of people continues to have strong ties with the natural environment. Undeveloped landscapes offer a refuge from the modern world, a place where people can reconnect with nature and escape the stresses of everyday life. Many people retreat to forests because they foster a sense of oneness with nature which can stimulate contemplation and bring about inner peace.

While specific sites may be used in religious rituals, forests are often described as spiritual landscapes because they provide an experience of being related to, or in touch with, an 'other' that transcends their individual sense of self and gives their life a deeper meaning beyond an intellectual level (Schroeder 1992). Spiritual experiences in nature are generally intuitive or emotional and tend to create a sense of being caught up or carried away. Opportunities to explore and enjoy the scenic beauty of the natural environment have been known to fill and inspire people with a feeling, an idea, or a creative impulse. Forests have long served as inspiration for a wide range of artistic and cultural expressions, including: film, literature, photography, paintings, sculptures, music and dance, fashion, folklore, national symbols, and even architecture and advertisement (Rudolph de Groot et al. 2005).

Comments collected during public involvement indicated that Forest users highly valued the Francis Marion for contributing towards their mental and spiritual well-being. Numerous respondents reported relying on the Forest to decompress from daily stress and that the ability to reconnect with nature and rural life improved their quality of life. Other users disclosed that they valued the Forest as a spiritual resource and that its mere existence gave them great pleasure. The spiritual, inspirational, and aesthetic services supported by the Forest's natural landscape provide mental clarity and inspiration, and is attributed with improving the overall quality of life in surrounding communities.

Supporting Services

Supporting services are the underlying natural processes which sustain ecosystems and enable the production of all other ecosystem services. Initial scoping identified nutrient cycling as a key supporting services provided by the Francis Marion. While nutrient cycling on the Francis Marion National Forest takes place at an ecoregional level, nutrient cycling on the Forest feeds into global biogeochemical cycles.

Nutrient Cycling. Nutrient cycling is nature's way of recycling old life into new. Many nutrients, including water, carbon, nitrogen and phosphorus are stored, transformed, and cycled

through the Forest's soil via natural feedback loops. These feedback loops capture, store and convert energy and nutrients from decomposing organic and inorganic matter into new plant forms. The decomposition of organic forest matter replenishes soil nutrients and supports the natural fire regime by reducing the density of fuels. Nutrient cycling on the Francis Marion National Forest filters potential water pollutants in soil, and promotes soil biodiversity and fertility. The maintenance of soil fertility is a supporting service for the production of food, timber, fiber, and fuel. Current conditions and trends related to soil on the Francis Marion National Forest can be found in section 2.2.2, Soils."

7.1.1.3 Trends and Drivers

The Forest's ability to produce these beneficial services is largely influenced by its ability to complete ecological processes. System stressors and drivers affect ecological functions on the Forest and can have positive or negative effects on the Forest ecosystems. Drivers are major environmental forces that have large-scale influences on the natural system (e.g., climate, hydrology, and major natural disturbances); stressors, which are also drivers, are the human induced perturbations which have large or regional-scale influences on the natural system (e.g., water management, contaminants, exotic species) (Ogden et al. 2005). Chapter 3 "System Drivers" identifies and provides information regarding the primary system drivers and stressors on the Francis Marion National Forest. Drivers identified in this section included climate change, insects and disease, wildland fire/fuels, invasive species, natural vegetation succession, natural disturbances, and human disturbances.

As system drivers move Forest resources closer to or farther from desired conditions, these influences may improve or inhibit the ecological functions which facilitate ecosystem services. While the discussion of ecosystem services may provide a brief overview of factors influencing ecological trends on the Forest, a more thorough discussion of current conditions, trends, and system stressors affecting the provision of these services is included the sections referenced throughout this chapter.

In addition to the human disturbances discussed in section 3, rapid growth discussed in section 6 "Social and Economic Assessment" is also a very strong system driver. South Carolina's coastal Lowcountry, which includes the Francis Marion National Forest, is an amenity rich region whose historically rural landscape is becoming increasingly urbanized. Sprawling growth extending from the Charleston urban area has rapidly transformed the landscape of Charleston and Berkeley counties from minimally developed wildlands into large suburban communities. The Francis Marion has become an urban forest whose inholdings and adjacent tracks provide a unique opportunity to live in a natural setting surrounded by the great outdoors while maintaining an easy commute to the Charleston Metropolitan area. The continued conversion of rural and wild lands surrounding the Forest has fragmented and degraded the natural landscape and altered the social and economic landscape of local communities.

These open spaces, natural settings, and ecosystem goods and services provided by the Francis Marion continue to grow in importance as the State transitions from a rural to an increasingly urban environment. Recent trends have shown more and more people are moving from metropolitan areas to rural areas along the wildland-urban interface. Rapid development occurring in these ex-urban areas—rural areas beyond the built-up urban and contiguous suburban area—has caused significant losses in habitat and ecosystem services. Reductions in the quantity and quality of goods, services, and visitor opportunities provided by non-national forest lands creates greater demand for those provided by the Francis Marion, making it increasingly more difficult for the Forest to provide access to natural settings while sustaining

organisms and processes across its landscapes. As communities surrounding the Francis Marion National Forest continue to grow, conflicts between human development and ecosystem health and productivity are likely to arise. Increased use of Forest resources may have adverse effects on the quantity and quality of ecosystem services the Forest is able to provide.

8 Multiple Uses

8.1 Introduction

Since the establishment of the national forests, their use by the public and for the benefit of the public has been a key feature of both the legislation that established them and of more recent legislation that provides direction for their management. This conservation use ethic is in contrast to the national parks, which were established with mainly a preservation ethic.

The Organic Act of 1987 provided for the establishment of the national forests, then referred to as forest reserves. That act stated: "No public forest reservation shall be established, except to improve and protect the forest within the reservation, or for the purpose of securing favorable conditions of water flows, and to furnish a continuous supply of timber for the use and necessities of citizens of the United States…"

The Multiple Use-Sustained Yield Act of 1960 was the next major legislation directing management of the national forests. It states that "it is the policy of the Congress that the national forests are established and shall be administered for outdoor recreation, range, timber, watershed, and wildlife and fish purposes." The act defines multiple use and sustained yield as follows:

> *Multiple use* – "The management of all the various renewable surface resources of the national forests so that they are utilized in the combination that will best meet the needs of the American people…"
>
> *Sustained yield* – "…the achievement and maintenance in perpetuity of a high level annual or regular periodic output of the various renewable resources of the national forests without impairment of the productivity of the land."

The act also explicitly states that "The establishment and maintenance of areas of wilderness are consistent with the purposes and provisions of this Act."

The National Forest Management Act of 1976 (NFMA) provides direction for preparing land management plans for the national forests. It is actually an amendment to the Forest and Rangeland Renewable Resources Planning Act of 1974, which called for the management of renewable resources on national forest lands. The NFMA states that:

"In developing, maintaining, and revising plans for units of the national forest system pursuant to this section, the Secretary shall assure that such plans

> (1) provide for multiple use and sustained yield of the products and services obtained therefrom in accordance with the Multiple-Use, Sustained-Yield Act of 1960, and in particular, include coordination of outdoor recreation, range, timber, watershed, wildlife and fish, and wilderness; and timber, watershed, wildlife and fish, and wilderness…"

8.2 Recreation

See section 9 "Recreation."

8.3 Fish and Wildlife

8.3.1.1 Preliminary Findings

3. **The Francis Marion National Forest is one of the most biologically and ecologically diverse forested landscapes in the Southeast.** The Francis Marion National Forest provides critical habitat for reptiles and amphibians, and likely boasts some of the highest herpetofaunal species diversity in South Carolina. The Francis Marion National Forest is home to one of only three known populations of the federally threatened flatwoods salamander (*Ambystoma cingulatum*). The Forest also provides habitat for the Forest sensitive/State endangered Carolina gopher frog (*Lithobates capito*) and numerous State rare species of herpetofauna.

   Due to its significance to resident and migratory birds, the Francis Marion National Forest has been designated as an important bird area by both the National Audubon Society and the American Bird Conservancy. The Francis Marion serves as an important stopover and wintering ground for waterfowl and other migratory species.

4. **Based on findings in the The Economic Impact of South Carolina Natural Resources, "well-managed natural resources provide a magnet for human capital." In terms of economic impacts, fishing, hunting and wildlife watching have tremendous impacts on state and national economies.**

   As the human population continues to grow in the tri-county area of Berkeley, Charleston, and Dorchester, wildlife watching on the Francis Marion is anticipated to increase over the next 20 years. Opportunities to expand wildlife watching opportunities on the Francis Marion National Forest are numerous, and benefits to the local economy resulting from wildlife watching on the Forest can be significant.

   Combined, it is estimated that the total economic impact of fishing, hunting and wildlife viewing in South Carolina is over $3,794,000,000 per year, and these activities are directly responsible for approximately 44,672 jobs in South Carolina (South Carolina Department of Vocational Rehabilitation 2009).

   According to the 2011 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation report, wildlife recreationists spent $144.7 billion in 2011 on their activities, which equated to 1 percent of the gross domestic product.

5. **The Francis Marion National Forest is one of the few national forests that is adjacent to a national wildlife refuge and an ocean.** Together, the Francis Marion National Forest and Cape Romain National Wildlife Refuge provide the largest and most contiguous protected avian habitat in all of South Carolina.

6. **The Francis Marion National Forest has played a vital role in the hunting heritage and opportunities now found in South Carolina. No other Federal or state lands can boast of the hunting legacy that the Francis Marion has in South Carolina.** When the Forest was acquired in 1936 the last remaining populations of white-tailed deer and wild turkey were only found in remote mountainous and coastal forest areas. Wild game populations had become so depleted due to excessive hunting in the mid-1900s, that in 1948 President Truman, via Presidential Proclamation, established 50,600 acres on the Francis Marion as a wildlife sanctuary. In 1956, 20 years after acquisition,

the first deer and turkey hunts were held within the Francis Marion's special wildlife management area, and hunting has occurred across the Forest since this time.

The Francis Marion and Sumter National Forests are vital components of the wildlife management area program in South Carolina. Forest Service lands account for approximately 60 percent (629,906 acres) of the roughly 1.1 million acres enrolled in the wildlife management area program. Through a long lasting cooperative agreement, the South Carolina Department of Natural Resources (SCDNR) annually submits roughly 14 percent of the previous year's wildlife management area permit sales to the U.S. Forest Service, and directly assists with wildlife management activities on national forest lands in South Carolina.

7. **Hunting and fishing are two of the most popular recreational activities pursued on the Francis Marion National Forest.** According to the 2008 Francis Marion Sumter Visitor Use Report (page 20), hunting was the number one activity selected by respondents as the main purpose of their national forest visit. For the Southern Region as a whole, fishing was #3 and Hunting was #4 (see page 22 of the Region 8 Master Report). Other than economic impacts, there are non-monetary values derived from hunting, fishing, and wildlife watching on the Francis Marion National Forest. These values cannot be ascribed a financial figure, as they are directly tied to the emotional, spiritual and intellectual benefits derived from a nature experience. The Francis Marion National Forest manages approximately 15 recreational fishing ponds representing a total acreage of approximately 44 acres.
8. **On August 17, 2007, President George W. Bush signed Executive Order 13443: Facilitation of Hunting Heritage and Wildlife Conservation.** The Order directs Federal agencies "to facilitate the expansion and enhancement of hunting opportunities and the management of game species and their habitat." The Recreational Hunting and Wildlife Conservation Plan was developed in response to Executive Order 13443. As stated in The Recreational Hunting and Wildlife Conservation Plan, "hunting and recreational shooting with firearms and archery equipment are important elements of America's outdoor heritage, and are uniquely dependent upon public access to Federal, state, and private lands. Constraints on access have been identified as one of the leading impediments to sustaining and growing participation."
9. **Management of our wildlife openings and waterfowl areas on the Francis Marion National Forest contribute to and enhance wildlife related recreational opportunities.** Approximately 735 acres of terrestrial wildlife openings and 324 acres of greentree reservoirs and waterfowl impoundments are managed by the USDA Forest Service and various partners on the Francis Marion National Forest.

   Waterfowl hunting has traditionally been a sport of the wealthy, and few hunters have access to lands suitable for waterfowl hunting. As such, waterfowl hunting opportunities on public lands are critical for providing opportunities to those publics who do not have access to lands suitable for waterfowl hunting.

   R.K. Williams surveyed the Francis Marion National Forest in 1999 for potential waterfowl management areas. Funding for this project was provided by USDA Forest Service, U.S. Fish and Wildlife Service, National Wild Turkey Federation, Atlantic Coast Joint Venture, and Ducks Unlimited, Inc. This survey identified numerous opportunities for restoring and creating waterfowl management areas on the Francis Marion National Forest. However, very few waterfowl projects have been implemented since 1999.

10. **Hunting, especially deer hunting with dogs, has generated a significant amount of conflict with other recreational users and the public on the Francis Marion National Forest.** The Forest Service works diligently with SCDNR to minimize hunting conflicts on the Francis Marion and Sumter National Forests. Since the last plan revision, numerous steps have been taken to reduce the number of conflicts between hunters, private landowners, and other Forest users. Neither the Francis Marion nor SCDNR received any hunting complaints during the 2012/2013 deer season, so mitigation measures appear to be working.
11. **In order to promote floral and faunal diversity, it is critical that the Francis Marion National Forest try to burn whenever and wherever possible, as the vast majority of Francis Marion species and communities are dependent upon fire maintenance.** The highest potential for restoring longleaf pine on the Francis Marion National Forest with minimal impacts to proposed, endangered, threatened, and sensitive species exists within the dense loblolly pine stands that were regenerated after Hurricane Hugo.
12. **Longleaf pine and hydrologic restoration need to be the two highest priorities on the Forest during the next planning period.** Species such as the Carolina gopher frog and frosted flatwoods salamander are in a critical state throughout their range, and are highly susceptible to local extirpation without proper protection and habitat management. As such, continued monitoring and proper management is crucial for maintaining viable populations of these two species, as well as other herpetofauna.
13. **Roads can have significant adverse ecological and biological effects on amphibians and reptiles, as well as numerous other faunal groups.** Some heavily traveled paved roads on the Francis Marion National Forest cause significant amphibian and reptile mortality (i.e., Highway 17, Highway 41, Highway 402, Highway 45, and Steed Creek Road). As the human population continues to increase in the counties of Berkeley, Charleston and Dorchester, wildlife road mortality is expected to continue to increase as more vehicles are on the roads. Road impacts on wildlife need to be assessed on the Francis Marion National Forest in order to identify potential mitigation measures.

8.3.1.2 Introduction

The fish and wildlife on national forest lands are an important resource enjoyed by people in a variety of ways. Sections 2 and 3 describe the evaluation of ecological conditions that support fish and wildlife. The evaluation process for identifying at-risk species is in section 5. For purposes of this section, the focus of the assessment is on the contribution of fish and wildlife to social and economic sustainability.

Located in Charleston and Berkeley counties, South Carolina, the Francis Marion National Forest is one of the most biologically and ecologically diverse forested landscapes in the Southeast. The Francis Marion National Forest is comprised of several different landforms, ranging from swamps, floodplains, stream terraces, side slopes, and xeric ridges. The Forest contains a high diversity of natural communities ranging from dry longleaf pine/turkey oak woodland to clay-based Carolina bay wetlands. To date, over 1,600 species of plants have been documented on the Forest, which include 32 species of orchids, 22 species of ferns, and 12 species of carnivorous plants. Approximately 48 species of mammals, 250 species of birds, 43 species of amphibians and 58 species of reptiles are known to inhabit the Francis Marion National Forest.

The Francis Marion provides phenomenal natural-resource-related benefits to the state of South Carolina and the United States. Due to the biological diversity and benefits that the public derives from the Francis Marion National Forest, this assessment seeks to address all fish and wildlife that contribute to social and economic sustainability. As stated in the 1996 Revised Land and Resource Management Plan, "our goal is to provide for wildlife resource needs while servicing public interests and uses through habitat management that supports viable populations of all existing native wildlife species, and where opportunities exist, to enhance habitat for populations of animals that are commonly viewed, photographed, hunted or fished."

According to The Economic Impact of South Carolina Natural Resources,

> The natural environment is a primary attraction for skilled labor and more educated individuals who want opportunities for recreation, for themselves and their families. Creative people tend to be mobile and look for natural amenities. The value of these amenities is evident in their positive impact on the quality of life of South Carolina's residents. A higher quality of life means that residents are more likely to remain where they are, spend more of their time and money in the vicinity where they live, and will be less likely to move out of the region or state. Increasingly, scholarly research shows that talented people—the kind the state wants to retain—reside in places with quality natural resources-related amenities and recreation opportunities. Thus, well-managed natural resources provide a magnet for human capital.

Proposed, endangered and threatened and potential species of conservation concern species are addressed in section 5 "At-risk Species."

8.3.1.3 Fish and Wildlife Components of 1996 Forest Plan

The 1996 Forest plan stated the following with regards to fish and wildlife on the Francis Marion National Forest:

Goals

G-7 Protect and Manage Habitat for Sustainable Populations of Native Wildlife. The Francis Marion is home to many different species of wildlife. Our goal is to provide for wildlife resource needs while servicing public interests and uses through habitat management that supports viable populations of all existing native wildlife species and where opportunities exist, to enhance habitat for populations of animals that are commonly viewed, photographed, hunted or fished.

Forest Desired Future Condition

Economy: The Forest continues to contribute to the economic wellbeing of local communities. As a result of the extensive hurricane damage, there is a major reduction in monetary returns to the counties from timber receipts. The economic diversity of the local economy is increased, while the economic dependency associated with wood and paper manufacturing decreases slightly. There is an increase in income and jobs related to non-timber products such as recreation and wildlife. Wildlife management area fees and recreational user fees comprise a larger portion of the revenue collected.

Wildlife and Fisheries: Both game and non-game wildlife species are abundant. Forage and cover quality and quantity have improved. A good distribution in tree age classes provides for a variety of habitat. Both early and late successional habitats are available after the first few decades. Prescribed fire maintains the early seral condition in the next 10 years. About

20 percent of the Forest is at least 90 years old at the end of the first decade. This increases to over 50 percent of the Forest in the long term ensuring adequate habitat for late successional species.

Objectives

Objective 12: Maintain 5,000 to 10,000 acres in early successional habitat (0 to 3 year age class, permanent openings, wildlife openings, road rights-of-way, utility rights-of-way) in the short and long term.

Objective 13: Maintain or expand existing proposed, endangered, threatened and sensitive (PETS), and management indicator species and communities (MIS). (For MIS population and habitat objectives, see 5-6–5-8.)

Objective 16: Sustain the habitat capability for the following population densities of wildlife species in the long term in suitable habitat: eastern wild turkey, one turkey per 75 acres; white-tailed deer, one deer per 30 to 40 acres; and northern bobwhite, one quail per 10 acres.

Forestwide Standards and Guidelines

FW-16 (R8–VM) Burns are planned to achieve their most desirable distribution for wildlife habitat and to try to break up large, continuous fuel types. When consistent with burning objectives, burns are done to create a mosaic pattern of fuel types that complements fuel treatment and wildlife objectives.

FW-37 (R8–VM) Herbicides are applied according to labeling information and the site-specific analysis done for projects. This labeling and analysis are used to choose the herbicide, rate, and application method for the site. They are also used to select measures to protect human and wildlife health, non-target vegetation, water, soil, and threatened, endangered, proposed, and sensitive species. Site conditions may require stricter constraints than those on the label, but labeling standards are never relaxed.

FW-58 (R8-SPB) Retain selected hardwoods in an uncut or untreated state for wildlife and plant diversity.

FW-150 During wildlife stand improvement (WSI) and site preparation, selected groups of overstory and understory vegetation are managed to assure a variety of soft mast, hard mast and cover species.

FW-151 During TSI, WSI and site preparation, at least tow standing dead snags (greater than 12 inches) are retained per acre. Give priority to the largest snags available and to hardwood species; however, pine snags may be substituted if appropriate hardwoods are not available. Appropriate treatments are used to create snags where natural snags are lacking.

Forest Plan Amendment

A Forest plan amendment resulting in a change in the list of management indicator species was signed in April, 2003. The MIS list was reduced to 11 species, 9 animals and 2 plants, in order to increase the efficiency and effectiveness of the monitoring program and of project effects analysis. Habitats represented include early succession, pine forests and woodlands, upland hardwoods, ephemeral wetlands and bottomland hardwoods. Demand species and viability concern species are also represented.

Amphibians and Reptiles

The Francis Marion National Forest provides critical habitat for reptiles and amphibians, and likely boasts some of the highest herpetofaunal species diversity in South Carolina. Approximately 43 species of amphibians and 58 species of reptiles are known to inhabit the Forest. Out of the 100 species of herpetofauna documented on the Forest, 24 are anurans, 19 are salamanders, 36 are snakes, 10 are turtles, and 11 are lizards. The Francis Marion National Forest is home to one of only three known populations of the federally threatened flatwoods salamander (*Ambystoma cingulatum*). The Forest also provides habitat for the Forest sensitive/state endangered Carolina gopher frog (*Lithobates capito*) and numerous State rare species of herpetofauna.

Isolated palustrine wetlands, which occur throughout the Francis Marion National Forest, are among the most important and imperiled herpetofaunal habitats in the Southeast. Contribution of isolated wetlands to regional biodiversity has been severely overlooked and there are major gaps constraining the development of management regimes that protect these important habitats. Alarming population declines for species such as the flatwoods salamander, Carolina gopher frog, and striped newt (*Notophthalmus perstriatus*) have been directly attributed to loss and/or degradation of seasonally flooded isolated wetlands and their adjacent uplands. At present, there are no Federal measures in place to protect the filling of isolated wetlands on private property. As a result of the Supreme Court's decision in Solid Waste Agency of Northern Cook County *v.* U.S. Army Corps of Engineers (SWANCC), 531 U.S. 159, (2001), the Army Corps of Engineers no longer has authority under the Clean Water Act to require permits for the dredging or filling of isolated wetlands.

It is now up to the individual states to implement regulatory measures protecting isolated wetlands. Many states have implemented internal measures to supplement the Supreme Court's decision, but South Carolina still has not as of 2013. Based on documented occurrences, the Francis Marion National Forest supports numerous priority species listed in the South Carolina Comprehensive Wildlife Conservation Strategy such as the southern hognose snake (*Heterdon simus*), timber rattlesnake (*Crotalus horridus*), eastern diamondback rattlesnake (*Crotalus adamanteus*), pine woods snake (*Rhadinaea flavilata*), pine snake (*Pituophis melanoleucus*), chicken turtle (*Deirochelys reticularia*), spotted turtle (*Clemmys guttata*), and eastern tiger salamander (*Ambystoma tigrinum*). Although most herpetofauna are not consumed, the Francis Marion National Forest is nationally known for its herpetofaunal diversity.

Unfortunately, this designation does not come without potential negative consequences. Due the high herpetofaunal diversity found on the Francis Marion National Forest, collectors have and continue to collect reptiles and amphibians on the Forest. Other than alligators, turtles, and State-protected species, there is no State law in place to regulate the collection of reptiles and amphibians. In fact, the only time that the State of South Carolina requires a permit for collecting reptiles and amphibians is for protected species or scientific collection. Current Forest Service laws pertaining to wildlife collections are somewhat vague. According to 36 CFR 261.8(a): "Hunting trapping, fishing, catching, molesting, killing, or having in possession any kind of wild animal, bird, or fish, or taking the eggs of any such bird is prohibited. However, the aforementioned activities are only prohibited to the extent that Federal or State law is violated. As such, in the State of South Carolina, the Forest Service currently has limited regulatory mechanisms in place to regulate the collection of reptiles or amphibians as long as no Federal or State law is violated. Because of this, enforcement and regulation of reptile and amphibian collections has been minimal on the Francis Marion.

Because the Francis Marion is so important for conserving reptiles and amphibians, it has been nominated to be a priority amphibian and reptile conservation area (PARCA). Reptiles and amphibians are experiencing significant declines worldwide. Habitat loss and fragmentation are two of the biggest threats reptiles and amphibians. The PARCA project is an initiative of Partners in Amphibian and Reptile Conservation (PARC) to develop a network of focus areas designed specifically for the conservation of reptiles and amphibians. Areas are nominated using scientific criteria and expert review, and focus on concepts such as species rarity, species richness, regional responsibility, and landscape integrity. The designation of a PARCA is completely non-regulatory. The primary purpose of PARCAs is to raise public awareness and spark voluntary protection by landowners and major conservation partners. PARCAs are not designed to compete with existing landscape biodiversity initiatives, but instead, are meant to complement existing initiatives. The PARCA model is very similar to that of the important bird areas program developed by Partners In Flight. PARCAs are intended to be coordinated nationally but implemented locally at the state scale.

Avifauna

Over 250 species of birds have been documented on the Francis Marion National Forest. Due to its significance to resident and migratory birds, the Francis Marion National Forest has been designated as an important bird area by both the National Audubon Society and the American Bird Conservancy. Important bird areas are defined as sites that have been documented to support significant populations of particular species or a significant diversity of species.

- The Francis Marion National Forest provides essential stopover habitat for autumn and spring migrating birds, as well as critical breeding habitat.
- Three species known to occur on the Francis Marion and listed on the National Audubon's red list include the red-cockaded woodpecker, Swainson's warbler (*Limnothlypis swainsonii*) and Bachman's sparrow (*Aimophila aestivalis*).
- Approximately 12 species of migratory birds listed on the National Audubon's yellow list have been documented on the Forest.
- Other species found on the Forest with high conservation priority are the black-throated green warbler (*Dendroica virens*), Swainson's warbler (*Limnothlypis swainsonii*), prothonotary warbler (*Protonotaria citrea*), worm-eating warbler (*Helmitheros vermivora*), brown-headed nuthatch (*Sitta pusilla*), red-codaded woodpecker, Chuck-will's widow (*Caprimulgus carolinensis*), yellow-throated warbler (*Dendroica dominica*), and northern parula (*Parula Americana*).
- Wading bird rookeries can be found throughout the Francis Marion National Forest. However, sensitive habitats such as rookeries need closer attention and protection. Personal observations of a rookery off of Steed Creek and Highway 17 have shown steady nesting declines since 2006. Such declines are likely correlated with increased wildlife viewing in the rookery and traffic on the adjacent Forest Service road.

Poorly drained areas such as swamps, floodplains, pond cypress ponds, swamp tupelo ponds, pocosins, depression meadows, beaver ponds, wet flatwoods and tidal marshes provide wintering and breeding habitat for many species of waterfowl, raptors, wading birds, neo-tropical migrant songbirds and small and large native mammals. There are extensive areas of Francis Marion National Forest that provide foraging and nesting habitats for ospreys (*Pandion haliaetus*) and southern bald eagles (*Haliaetus leucocephalus*). One of the largest and northernmost established nesting populations of the American swallow-tailed kite (*Elanoides forficatus*) is found on Francis Marion National Forest.

The Francis Marion serves as an important stopover and wintering ground for waterfowl and other migratory species. The primary species of waterfowl utilizing the wetland habitats on the Francis Marion National Forest are the wood duck, mallard, and green-winged teal. American wigeon, gadwall, blue-winged teal and hooded mergansers are encountered in the existing habitats although in much lower numbers. Waterfowl abundance and species composition will vary from year to year depending upon breeding success, habitat conditions, time of year, weather conditions and other factors. Regarding year-round residents, wetland habitats on the Francis Marion National Forest provide ideal foraging and nesting habitats for the wood duck (*Aix sponsa*).

The Francis Marion National Forest falls within the South Atlantic Joint Venture's CAWS Basin Sub-Focus Waterfowl Area, and U.S. Fish and Wildlife Service Bird Conservation Region 27. Eight of the aforementioned waterfowl species are on SAMBI's Highest Priority List. Wetlands on the Francis Marion National Forest provide good habitat for wintering species such as the mallard and American black duck. Both of these species are on SAMBI's highest priority list.

Table 8-1. Waterfowl species documented during winter counts on the Francis Marion National Forest

Species	Species (Continued)
Tundra swan (*Cygnus columbianus*)	Canada goose (*Branta canadensis*)
Green-winged teal (*Anas crecca*)	American coot (*Fulica americana*)
Mallard (*Anas platyrhynchos*)	Blue-winged teal (*Anas discors*)
Gadwall (*Anas strepera*)	Canvasback (*Aythya valisineria*)
Ring-necked duck (*Aythya collaris*)	Bufflehead (*Bucephala albeola*)
Hooded merganser (*Mergus cucullatus*)	Ruddy duck (*Oxyura jamaicensis*).
Snow goose (*Chen caerulescens*)	Wood duck (*Aix sponsa*)
American black duck (*Anas rubripes*)	Mottled duck (*Anas fulvigula*)
Northern pintail (*Anas acuta*)	Northern shoveler (*Anas clypeata*)
American wigeon (*Anas americana*)	Redhead (*Aythya americana*)
Lesser scaup (*Aythya affinis*)	Black-bellied whistling-duck (*Dendrocygna autumnalis*)
Red-breasted merganser (*Mergus serrator*)	

American oyster catchers on Cape Romain NWR

The Francis Marion National Forest is one of the few national forests directly adjacent to a national wildlife refuge and an ocean. Together, the Francis Marion National Forest and Cape Romain National Wildlife Refuge provide the largest and most contiguous protected avian habitat in all of South Carolina. Cape Romain National Wildlife Refuge, a designated Western Hemispheric Shorebird Reserve, provides habitat for high concentrations of American oystercatchers (*Haematopus palliates*), red knot (*Calidris canutus*), Wilson's plover (*Charadrius wilsonia*), short-billed dowitcher (*Limnodromus griseus*), and numerous other priority bird species.

Being directly adjacent to the Atlantic Ocean and protected marshes of Cape Romain National Wildlife Refuge, the Francis Marion National Forest is a premier birding location. Due to its close proximity to metropolitan and tourist destinations such as Mount Pleasant, Charleston, and Myrtle Beach, the Francis Marion National Forest offers exceptional birding/wildlife watching opportunities for thousands of people each year.

Wildlife watching is one of the most popular types of outdoor recreation in the United States. According to the 2011 National Survey of Fishing, Hunting and Wildlife-Associated Recreation, there were an estimated 71.8 million wildlife watchers 16 years of age and older in the United States as of 2011. This number represents a 9 percent increase in wildlife watchers since the 2001 National Survey of Fishing, Hunting and Wildlife-Associated Recreation.

Wildlife viewing blind at South Tibwin

The 2011 National Survey of Fishing, Hunting and Wildlife-Associated Recreation indicates that there were an estimated 46.7 million birders 16 years of age and older in the United States. Approximately 17.8 million of these birders take trips away from their homes to bird. According to the 2005 South Carolina Recreation Participation and Preference Study, bird watching and wildlife watching had the highest participation trips out of the categories reported (SCPRT 2005; South Carolina Division of Research 2009). In South Carolina, approximately 944,000 residents participated in wildlife watching activities during 2011, which represents roughly 12 percent of the population.

There were an estimated 1.1 million resident and non-resident wildlife watchers in South Carolina during 2011 (USDI Fish and Wildlife Service 2012). Total dollars spent wildlife watching in South Carolina during 2011 was estimated to be $467,679,000 (USDI Fish and Wildlife Service 2012). Nationwide, it is estimated that wildlife watchers spend upwards of $54.9 billion on wildlife watching USDI Fish and Wildlife Service 2012).

Bird watching along the coast

Fishing on the Francis Marion National Forest

The Francis Marion National Forest provides phenomenal wildlife watching opportunities to the public, and already has an impact on the local economy. As the human population continues to grow in the tri-county area of Berkeley, Charleston and Dorchester, wildlife watching on the Francis Marion is anticipated to increase over the next 20 years. Opportunities to expand wildlife watching opportunities on the Francis Marion National Forest are numerous, and benefits to the local economy resulting from wildlife watching on the Francis Marion National Forest can be significant. The Forest Service property known as Tibwin offers a perfect example of how wildlife watching can be expanded upon with partners. Tibwin offers outstanding wildlife watching opportunities, and is convenient to the public. To date, over 200 species of birds have been documented on Tibwin alone. There are miles and miles of trails that wind through Tibwin and its diversity of habitats. Charleston County Parks and Recreation now owns a property directly adjacent to North Tibwin, which will eventually become a new county park. By partnering with Charleston County Parks and Recreation, Tibwin and the future county park site could offer some of the best hiking and wildlife watching opportunities in Charleston and Berkeley counties. With proper foresight, planning and direction, ecotourism related activities on the Francis Marion National Forest could offer a huge boost to the local economy.

Hunting and Fishing

Hunting and fishing in South Carolina is regulated by the South Carolina Department of Natural Resources (SCDNR). However, the Forest Service and SCDNR work collaboratively to ensure that quality hunting and fishing opportunities exist on the Francis Marion and Sumter National Forests. Hunting and fishing are two of the most popular recreational activities pursued on the Francis Marion National Forest, and both activities play a vital role in social and economic sustainability.

There are both fresh and salt water fishing opportunities on the Francis Marion National Forest. Huger Creek, Nicholson Creek, Turkey Creek, Wambaw Creek, Chicken Creek, Echaw Creek, Awendaw Creek, Guerin Creek, Santee River, and the Intracoastal Waterway are some of the most popular fishing spots on the Francis Marion National Forest. Santee River and most of the creeks on the Francis Marion National Forest are best accessed via boat. Some creeks are impassable in many areas due to downed trees, so small canoes and kayaks are usually the best options for fishing in the creeks. Other streams popular with local anglers include Chicken and Echaw creeks. The Santee River is the easternmost boundary of the Francis Marion National Forest, and offers good fishing opportunities, especially for those anglers with boats. Bream, bass, striped bass, crappie, catfish, and shad are the favored species.

The lower portion of the Santee River along with Awendaw Creek, Guerin Creek, and the Intracoastal Waterway, provide saltwater fishing opportunities for popular game fish such as red drum, spot and sea trout. Guillard Lake, an old oxbow lake adjacent to the Santee River, offers 10 acres of fishing for a variety of species. These species are usually similar to those found in the river. The Francis Marion National Forest manages approximately 15 recreational fishing ponds representing about 44 acres.

Hellhole Reserve Waterfowl Improvement Project

Fish populations and water quality parameters within the managed fish ponds are monitored and managed periodically in order to provide quality fishing experiences. Managed fish ponds were last monitored during 2009. A total of 15 ponds were scheduled for fish population balance assessment, basic water quality survey, and an aquatic plant survey during 2009. Appropriate management recommendations were summarized for each pond based on survey results. A total of 13 ponds were electro-fished. Two ponds had balanced bass: bluegill populations, 10 ponds were bass-crowded or near balanced and 1 pond was bream-crowded. Twelve ponds would require the addition of lime to correct low alkalinity values, and were limed during 2013. Ten ponds had some type of aquatic vegetation present, and were in need of vegetation management. With the exception of at least one pond, sterile triploid grass carp were stocked within the managed ponds, and were able to control most aquatic vegetation problems.

The Francis Marion National Forest has played a vital role in the hunting heritage and opportunities now found in South Carolina. No other Federal or state lands can boast of the hunting legacy that the Francis Marion has in South Carolina. When it was acquired in 1936, the last remaining populations of white-tailed deer and wild turkey were only found in remote mountainous and coastal forest areas. In fact, wild game populations had become so depleted due to excessive hunting, that President Truman, via Presidential Proclamation, established 50,600 acres on the Francis Marion as a wildlife sanctuary in 1948.

Turkey feather found on the Francis Marion National Forest

A significant portion of this sanctuary occurred in what is now called the Waterhorn Wildlife Management Area, and is where many of the first white-tailed deer and eastern wild turkeys were translocated from when the State began restoring populations throughout South Carolina. One of the earliest cooperative agreements between the U.S. Forest Service and a state agency was also established in 1948, when both agencies cooperatively managed the Waterhorn Area. In 1956, 20 years after acquisition, the first deer and turkey hunts were held within the Francis Marion's special wildlife management area, and hunting has occurred across the Forest since this time. In 1956

Francis Marion's Hellhole Reserve became the first waterfowl management area within the Forest Service's Southern Region.

Hunting was the number one activity selected by respondents as the main purpose of their Forest visit during the 2008 Francis Marion-Sumter Visitor Use Report (page 20). For the Southern Region as a whole, fishing was #3 and Hunting was #4 (page 22 of the Region 8 Master Report). Data such as this definitely supports the Forest Service's efforts to provide quality hunting and fishing opportunities to the public on the Francis Marion.

Due to the diversity of habitats found on the Francis Marion National Forest, hunters are able to pursue game animals such as white-tailed deer, waterfowl, eastern wild turkey, northern bobwhite, American woodcock, and numerous other small game species. All huntable areas of the Francis Marion are enrolled in the South Carolina Wildlife Management Area program. The Francis Marion and Sumter National Forests are vital components of the wildlife management area program in South Carolina. Forest Service lands account for approximately 60 percent (629,906 acres) of the roughly 1.1 million acres enrolled in the wildlife management area program.

Lease fees, generated by the sale of wildlife management area permits, are paid to wildlife management area landowners annually. Through a long lasting cooperative agreement, the South Carolina Department of Natural Resources (SCDNR) annually submits roughly 14 percent of the previous year's wildlife management area permit sales to the U.S. Forest Service, and directly assists with wildlife management activities on national forest lands in South Carolina. Funds received from the wildlife management area program are used for a plethora of fish and wildlife management activities on the Francis Marion and Sumter National Forests. With steadily decreasing appropriated funds, these wildlife management area proceeds have been vitally important to the Francis Marion and Sumter National Forests' wildlife management program. Without this funding source, quality public hunting and fishing opportunities would not be feasible on the national forests in South Carolina.

According to the 2011 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation report, wildlife recreationists spent $144.7 billion in 2011 on their activities, which equated to 1 percent of the gross domestic product. Of the 13.7 million hunters that took to the field in 2011, 11.6 million hunted big game, 4.5 million hunted small game, 2.6 million hunted migratory birds, and 2.2 million other animals (USDI Fish and Wildlife Service 2012). Of the 33.1 million anglers that fished, 27.5 million freshwater fished and 8.9 million saltwater fished (USDI Fish and Wildlife Service 2012).

Fishing, hunting, and wildlife watching have tremendous impacts on state and national economies. Business generated by hunters and anglers is extremely important to rural communities. Nationally, over a half-million jobs in America are supported by hunters alone (International Association of Fish and Wildlife Agencies 2002).

Combined, hunting and fishing expenditures in the U.S. were estimated to be in excess of $75.8 billion during 2011 (USDI Fish and Wildlife Service 2012). On average, anglers spent approximately $1,261 per angler, and hunters spent $2,484 per hunter during 2011 (USDI Fish and Wildlife Service 2012) Combined, it is estimated that the total economic impact of fishing, hunting and wildlife viewing in South Carolina is over $3,794,000,000 per year, and these activities are directly responsible for approximately 44,672 jobs in South Carolina (South Carolina Department of Vocational Rehabilitation 2009).

Regarding all wildlife associated recreation, the number of sportspersons rose from 33.9 million in 2006 to 37.4 million in 2011 (USDI Fish and Wildlife Service 2012). Results published by USDI Fish and Wildlife Service (2012) indicate that 33.1 million people fished, 13.7 million hunted, and 71.8 million participated in at least one type of wildlife-watching activity such as observing, feeding, and photographing wildlife during 2011. More than 90 million U.S. residents 16 years old and older participated in some form of wildlife-related recreation in 2011. Total participants in wildlife-related recreation are up 3 percent from 2006 results. The increase was primarily among those who fished and hunted (USDI Fish and Wildlife Service 2012).

According to the 2005 South Carolina Recreation Participation and Preference Study (SCRPPS) and the 2011 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation report, there appear to be age, gender and racial differences with regards to participation in traditional outdoor sports such as fishing and hunting. As stated in the 2005 SCRPPS study, a much higher percentage of South Carolina men reported that they had hunted in the past 12 months when compared to women (24.0 percent vs. 3.8 percent), participated in other shooting sports (18.4 percent vs. 5.9 percent), or participated in hunting dog field trials (3.8 percent vs. 0.8 percent).

According to the SCRPPS 2005 results, men were also much more likely than women to have fished in fresh water (51.8 percent vs. 23.4 percent) as well as in salt water (22.1 percent vs. 10.7 percent), and to have been shell fishing or shrimping (8.8 percent vs. 5.5 percent). Nationally, 73 percent (24.2 million) of all anglers appear to be male and 27 percent (8.9 million) were female (USDI Fish and Wildlife Service 2012). Male hunters in the United States make up approximately 89 percent (12.2 million) of all hunters and 11 percent (1.5 million) are females (USDI Fish and Wildlife Service 2012).

According to the 2005 SCRPPS report, Whites appear to be more likely than Blacks to participate in traditional outdoor recreational activities such as camping or hunting. A higher percentage of Whites than Blacks reported camping (30.4 percent vs. 7.0 percent), hiking (24.4 percent vs. 4.7 percent), hunting (17.8 percent vs. 5.2 percent), other shooting sports (15.5 percent vs. 4.2 percent), and participating in hunting dog field trials (2.9 percent vs. 0.8 percent). A higher percentage of Whites than Blacks also reported visiting historical sites (57.4 percent vs. 42.0 percent) or an unusual natural feature (42.1 percent vs.17.8 percent), bird watching (23.5 percent vs. 13.2 percent) or wildlife watching (39.7 percent vs. 18.7 percent), as well as off-road vehicle riding (25.5 percent vs. 18.7 percent), and horseback riding (11.2 percent vs. 4.2 percent). At 33.2 percent and 39 percent respectively, differences between Black and White respondents were fairly equal with regards to freshwater fishing (SCRPPS 2005).

The following excerpt from the 2008 Francis Marion-Sumter Visitor Use Report provides useful information concerning general expenditures associated with recreation on the Francis Marion National Forest:

> The spending that occurs on a recreation trip is greatly influenced by the type of recreation trip taken. For example, visitors on overnight trips away from home typically have to pay for some form of lodging (e.g., hotel/motel rooms, fees in a developed campground, etc.) while those on day trips do not. In addition, visitors on overnight trips will generally have to purchase more food during their trip (in restaurants or grocery stores) than visitors on day trips. Visitors who have not traveled far from home to the recreation location usually spend less than visitors traveling longer distances, especially on items such as fuel and food. Analysis of spending patterns has shown that a good way to construct segments of the visitor market with consistent spending patterns is the following seven groupings:

1. local visitors on day trips,
2. local visitors on overnight trips staying in lodging on the national forest,
3. local visitors on overnight trips staying in lodging off the national forest, and
4. non-local visitors on day trips,
5. non-local visitors on overnight trips staying in lodging on the national forest,
6. non-local visitors on overnight trips staying in lodging off the forest,
7. non-primary visitors.

> Local visitors are those who travel less than 50 road miles from home to the recreation site visited and non-local visitors are those who travel greater than 50 road miles to the recreation site visited. Non-primary visitors are those for whom the primary purpose of their trip is something other than recreating on that national forest. Over 80 percent of the FMS visits are people on day trips away from home, including nearly 70 percent who are local area residents. Just over 16 percent of the visits spend the night while away from their home. Of those, over 13 percent spend the night within 50 miles of the forest. Most that spend the night in the area do so in Private campgrounds not on the forest or a private home of a friend or relative. About half of the visiting parties spend $45 or less per party per visit. Almost one-third of the visiting population comes from households in the $25,000 to $49,999 range; about 22 percent come from households in the $50,000 to $74,999 range.

On August 17, 2007, President George W. Bush signed Executive Order 13443: Facilitation of Hunting Heritage and Wildlife Conservation. The Order directs Federal agencies "to facilitate the expansion and enhancement of hunting opportunities and the management of game species and their habitat." The Recreational Hunting and Wildlife Conservation Plan, as directed by Executive Order 13443, specifically states:

> Authorize federal agencies to retain receipts from the sale of woody biomass to provide priority funding toward habitat restoration in areas impacted by harvest. The remaining receipts would be used to fund the Secure Rural Schools program, additional forest health projects, and to provide access for hunting and other wildlife dependent recreation.

As stated in The Recreational Hunting and Wildlife Conservation Plan, "Hunting and recreational shooting with firearms and archery equipment are important elements of America's outdoor heritage, and are uniquely dependent upon public access to Federal, state, and private lands. Constraints on access have been identified as one of the leading impediments to sustaining and growing participation."

The Francis Marion National Forest, in cooperation with partners such as the National Wild Turkey Federation, SCDNR, Ducks Unlimited, and Quail Forever, manages approximately 735 acres of terrestrial wildlife openings and 324 acres of greentree reservoirs and waterfowl impoundments on the Francis Marion National Forest. Management of our wildlife openings and waterfowl areas on the Francis Marion National Forest contribute to and enhance wildlife related recreational opportunities. Wildlife openings and waterfowl areas make up less than 0.4 percent of the total acreage on the Francis Marion National Forest, but provide the following benefits: (1) unique hunting opportunities, (2) wildlife watching opportunities, (3) supplemental foods during key wildlife stress periods, (4) preferred habitats that are in relatively short supply

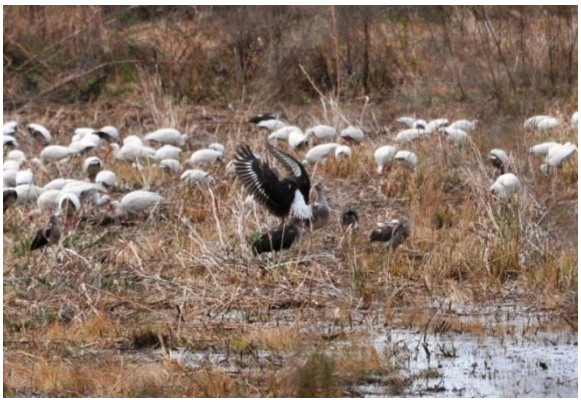
(i.e., wintering and breeding waterfowl habitat), and (5) higher quality foods than what are traditionally found on the Francis Marion National Forest.

Bald eagle and waterfowl at Tibwin Impoundment

The Francis Marion National Forest manages approximately 324 acres of waterfowl impoundments and greentree reservoirs. Currently there are approximately 90 acres of managed impoundments in compartment 217 (Tibwin Plantation), 15 acres in compartment 80 (Little Hellhole Reservoir), 110 acres managed as greentree reservoirs in compartment 70 (Nicholson Creek Greentree Reservoirs), a 59-acre greentree reservoir in compartment 57 (Cane Gully Greentree Reservoir), and a 50-acre greentree reservoir in compartment 209 (I'on Swamp Greentree Reservoir).

The 90 acres of impoundments in compartment 217 have only been hunted once since the USFS acquired Tibwin. Tibwin impoundments provide phenomenal resting and foraging areas for waterfowl, wading birds, and shorebirds.

These impoundments also serve as refuges for wintering waterfowl to escape hunting pressure on adjacent properties open to hunting. Waterfowl hunting has traditionally been a sport of the wealthy, and few hunters have access to lands suitable for waterfowl hunting. As such, waterfowl hunting opportunities on public lands are critical for providing opportunities to those publics who do not have access to lands suitable for waterfowl hunting.



White ibis foraging in Tibwin waterfowl impoundment

R.K. Williams surveyed the Francis Marion National Forest in 1999 for potential waterfowl management areas. Funding for this project was provided by USDA Forest Service, U.S. Department of Interior, Fish and Wildlife Service, Region 4, National Wild Turkey Federation, Atlantic Coast Joint Venture, and Ducks Unlimited, Inc. This survey identified numerous opportunities for restoring and creating waterfowl management areas on the Francis Marion National Forest. However, very few waterfowl projects have been implemented since 1999. As such, there are numerous opportunities to enhance waterfowl hunting and waterfowl viewing opportunities on the Francis Marion National Forest.

With so many users utilizing the Francis Marion National Forest throughout the year, conflicts between recreational users and the public do occur. Hunting, especially deer hunting with dogs, has generated a significant amount of conflict with other recreational users and the public on the Francis Marion National Forest. During recent public meetings that the Francis Marion National Forest hosted during 2012, several individuals and one permitted outfitter guide voiced their concerns about minimizing conflicts between hunters and other user groups. The Forest Service

works diligently with SCDNR to minimize hunting conflicts on the Francis Marion and Sumter National Forests. Forest Service and SCDNR employees have met numerous times with private landowners concerned about dog deer hunting issues, especially landowners concentrated in the Jamestown area of the Francis Marion National Forest.

Since the last Forest plan revision in 1996, SCDNR, in collaboration with the Forest Service, has significantly reduced and reconfigured dog deer hunting dates on the Francis Marion National Forest. At the time of the last plan revision, there were approximately 78 dog deer hunt dates on the Wambaw, Santee, and Northampton hunt units. In order to minimize conflicts with private landowners and other Francis Marion National Forest recreational users, the number of dog deer hunting days were reduced from 78 to 39 during the 2008/2009 deer season. Since this time, the Forest Service and SCDNR have continued to maintain relationships with adjacent private landowners, and responded to hunting issues on the Francis Marion National Forest in a timely manner. As of the 2012/2013 deer season, there are 23 days of dog deer hunting on the Francis Marion National Forest, which are spread out across the Hellhole, Wambaw, Santee, and Northampton hunt units.

Since the last plan revision, the Forest Service has agreed to close sections of the Wambaw Cycle Trail on days that dog deer hunts are occurring on the Northampton and Wambaw wildlife management areas. This has greatly decreased the potential for conflicts between dog deer hunters and trail users. The maximum number of deer that may be harvested on the Francis Marion National Forest have been reduced from 8 to 4, and firearms season for deer does not begin on the Francis Marion National Forest until at least October 1. There are 4 days of deer dog hunts on the Francis Marion National Forest during September. As of 2013, archery is the only allowable method of take on any of the Francis Marion wildlife management areas from 1 September to 31 October.

Up until 2010, firearms season for deer started as early as August 15 on all Francis Marion wildlife management areas except the Hellhole Wildlife Management Area. Additionally, firearms either-sex deer hunting was allowed between 1 September and 1 January on all but the Hellhole Wildlife Management Area. Beginning with the 2010/2011 deer season, deer gun hunts were changed to occur from 1 October to 1 January on all of the Francis Marion wildlife management areas, with either-sex harvests allowed during this entire period as well. All of the recent changes were implemented to improve the deer hunting experience for wildlife management area users, as harvest records and spotlight surveys were indicating decreased population numbers

All of the aforementioned changes have significantly reduced the number of conflicts and complaints that the Forest Service once received with regards to hunting on the Francis Marion National Forest. In fact, other than the few comments received during 2012 public meetings, the Forest Service and SCDNR did not receive any complaints about dog deer hunting on the Francis Marion National Forest during the 2012/2013 deer season.

Other than economic impacts, there are non-monetary values derived from hunting, fishing, and wildlife watching on the Francis Marion National Forest. These values cannot be ascribed a financial figure, as they are directly tied to the emotional, spiritual, and intellectual benefits derived from a nature experience. What dollar values can one place on a young person observing a bald eagle for the first time, or a youth harvesting his or her first white-tailed deer? What is the dollar value of hearing Bachman's sparrows, prairie warblers, and red-cockaded woodpeckers calling in a recently burned longleaf pine savanna?

8.4 Timber

8.4.1.1 Preliminary Findings

1. According to Forest inventory and analysis (FIA) data there has been a large increase in timber inventory since the current Forest plan was signed. Comparing recent harvest levels for the Forest to both FIA growth estimates and to the long-term sustained yield estimate in the current Forest plan indicates that harvest levels are easily sustainable.

2. Data in the 2010 Resources Planning Act Assessment indicate that long-term timber demand is expected to remain steady or increase; however, projections into the future are uncertain.

3. The value of harvests from the Forest should increase due to the increasing size of trees harvested and due to an improving economy. The trajectory of the U.S. economy, however, is always subject to change.

4. Species composition of the Forest appears to have changed. This is based on a comparison of data shown in the 1991 Analysis of the Management Situation with 2013 database information. There is significantly less loblolly pine and significantly more bottomland hardwood and mixed pine-hardwood. Stand mapping and typing will be examined in more detail before plan revision.

5. A comparison of data from the same sources as the previous item shows that the age class distribution has shifted with time. Defined as forest stands 0 to 10 years of age, the amount of early successional, young-aged forest is quite low, comprising only about 0.1 percent of the Forest.

6. Related to the previous item, the need for first commercial thinning harvests is expected to decrease significantly after the next several years. Trees on the Forest are not only getting larger, but much of the needed first thinning has already been accomplished.

8.4.1.2 Existing Information

Timber Harvest as an Ecological and Fuels Management Tool

In addition to the continuing economic value it produces, timber harvest serves valuable functions in helping to achieve desired conditions, maintaining or restoring key ecosystem characteristics, improving forest resistance and resilience to pests, and reducing the risk of wildfire. Some examples of this are:

- Moderating tree densities to help create desired habitat for the endangered red-cockaded woodpecker.
- Removing species and individual trees that are less desired to move forests toward desired species composition and structure.
- Reducing tree densities in pine stands to make them less susceptible to southern pine beetle.
- Reducing tree densities in pine stands to make them less susceptible to damage from wildfire and to present less risk of wildfire spread than dense unthinned conditions.
- Serving as a tool to help restore longleaf pine.

- Serving as a tool to help restore pine savannas.
- Creating new young forest stands to provide diverse habitats, a flow of habitats over time, and resilience to wind events and pest outbreaks.
- Capturing carbon sequestered by the forest and increasing the carbon sequestered by the forest as an effect of creating young rapidly growing stands.
- Removing fuel that has accrued as tree biomass.

Timber Inventories, Demand and Values

The inventory of standing live trees has changed dramatically since Hurricane Hugo caused extensive damage to the Forest in 1989. From the Forest Inventory and Analysis (FIA) group FIDO tool, the 1993 inventory of live trees over 5.0 inches was estimated at 260 MMCF (million cubic feet). By 2011, this volume had increased almost 60 percent to 414 MMCF. The FIA 2011 estimate of annual growth for the Forest is approximately 18 MMCF per year. While not all of this is on lands suitable for timber production, it is roughly six times the annual harvest in recent years. The current Forest plan calculated the long term sustained yield capacity as 6.3 MMCF per year. From 2008 to 2012 the average amount of timber sold annually has been 3.3 MMCF per year.

The 2010 Resources Planning Act Assessment examines status, trends, and projections of various Forest resources and their uses. In Figure 66 of this assessment, projected U.S. harvest volumes show a long-term increase under all scenarios. Figure 70, likewise, projects a long-term increase in U.S. lumber consumption under all scenarios. Scenarios predict reduced consumption of paper and paperboard products. However, this reduced demand in products from smaller diameter trees is offset by increased demand for structural panels (oriented strand board) and wood energy.

On page 76 of the 2010 RPA Assessment, the document states: "Among RPA regions, the South has accounted for the largest share of domestic timber harvest in recent decades, producing 57 percent of US timber harvest in 2006, for example….In the RPA projections, the South Region continues to be the largest timber-producing region in the United States, accounting for at least one-half of total harvest throughout the projection period in all RPA scenarios."

Forestry is first in South Carolina among manufacturing industries in jobs (90,624) and payroll ($4.1 billion) according to the South Carolina Forestry Commission, Forest Management Facts document. By 2015 the State desires to increase forestry's economic impact from $17.4 billion to $20 billion and increase job numbers by about 12,000.

The Francis Marion's role in the timber supply and demand picture, while small in the context of global and regional markets, is nevertheless important to the local timber industry. Though the forest products industry has been through a continuing trend of consolidation, a strong, competitive market still exists. Strong local demand has been reflected by the fact that the Francis Marion has been able to sell all the live timber sales it has offered during the last many years.

The value of timber sold from the Francis Marion is likely to increase significantly in the coming years. The first reason is that the values in recent years reflect depressed prices due to economic recession. The second reason is that the trees on the Forest are rapidly moving into larger and more valuable size classes.

On private lands in the general area, conversions from pasture land to forest and higher productivity on some lands have helped local supply. However, increasing urbanization has been subtracting from the acreage of forest land. This trend may reduce local supply over time.

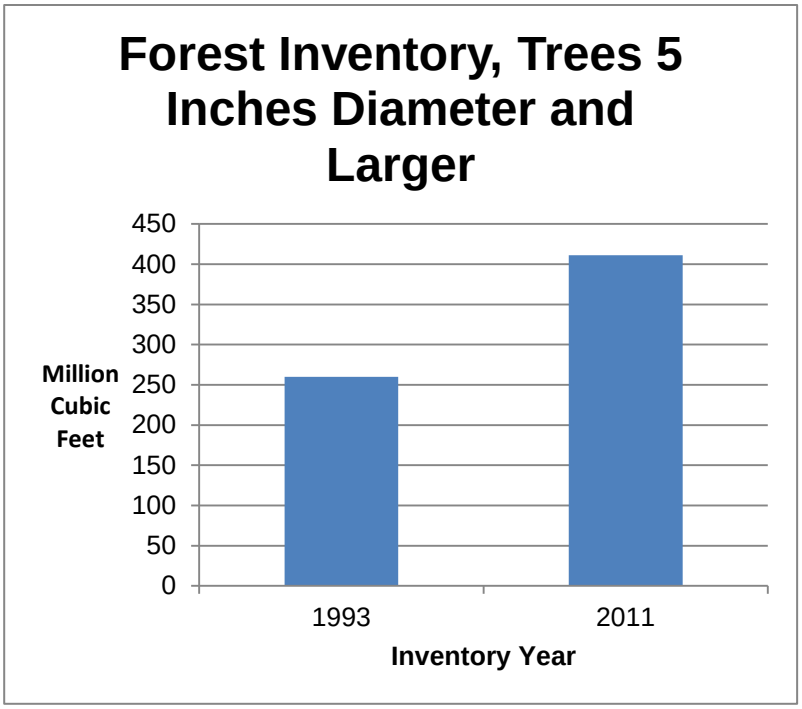


Figure 8-1. Change in standing timber volume from 1993 to 2011

Table 8-2. Volume of timber sold from the Francis Marion National Forest since 1996, and values in the last 5 years

Year	Volume sold (ccf)	Dollar Value ($)
1996	18,880	
1997	12,196	
1998	9,011	
1999	2,489	
2000	8,585	
2001	3,916	
2002	198	
2003	20,856	
2004	6,856	
2005	26,255	
2006	62,182	
2007	31,717	
2008	30,719	743,125
2009	33,261	532,899
2010	37,599	1,260,881
2012	32,601	957,176
2012	31,484	1,054,256

Sales of Hardwood Timber

The desired condition in the Forest plan envisioned that "The quantity and quality of hardwood products have increased, and the amount sold has also increased." This has not happened. Only minor amounts of hardwood products have been sold. A significant reason for this has been the priority of and focus on thinning pine stands due to the immediacy of that need, and because of objectives for red-cockaded woodpecker habitat.

Changes in Species Composition

As shown in Table 8-1, there seems to be significant changes in tree species since the previous Francis Marion Forest Plan.

Table 8-3. Percentage of forested acres within tree species categories

	Year, % of Forested Acreage		
Tree Species Group[1]	**1985**	**1990**	**2013**
Loblolly Pine[2]	53	50	36
Longleaf Pine[3]	17	16	20
Pond Pine	2	3	2
Mixed Hardwood and Pine	3	4	14
Upland Hardwood Species	3	1	0
Bottomland Hardwoods	8	8	15
Swamp Hardwoods[4]	16	18	13

[1] The tree species types do not represent pure stands of the species or group of species named. Single species types may contain up to 30 percent of other tree species within the same area.

[2] Contains a small acreage of slash pine.

[3] Includes mixed loblolly pine and longleaf pine.

[4] Swamp hardwood category includes cypress.

Although small amounts of the changes may be due to differences or accuracy in typing or the category that particular forest types may be assigned, there have been obvious large changes in the species composition of the Forest. Most of this is probably due to changes from Hurricane Hugo which were not picked up immediately.

While some of the increase in longleaf pine is due to restoration efforts, much of it is due to the inclusion of mixed loblolly pine/longleaf pine in this species group.

Loblolly pine is more susceptible to wind throw than longleaf pine. There was also a much larger area of loblolly pine available to suffer wind damage than other species simply because it occupied more acreage. It was especially vulnerable, as are all species, on wetter sites. On these sites, it is likely that hardwood advance regeneration would have been in place to take advantage of the disturbance, or in some cases remaining hardwoods in the canopy could have simply closed back in with crown expansion. In looking at data as early as the first monitoring reports it is apparent that these species shifts were reflected in forest typing and acreages soon after plan completion. Also, some of the acreage in mixed hardwood and pine may shift back into loblolly pine as stands grow and develop.

Cursory examination of stand mapping and typing has revealed some areas that need to be examined for accuracy and verification. This will be done in the coming months.

Plan Emphasis on First Commercial Thinnings

Objective O-9 in the current Francis Marion Land and Resource Management Plan is to create conditions on 38,000 to 50,000 acres of pine stands which release overcrowded live crowns…" This was a 10-year objective. From 1996 through 2012, the Francis Marion sold commercial thinning harvests on approximately 30,000 acres of land. Commercial thinning has been the sole focus of timber harvest on the Forest since a few years after Hurricane Hugo. This emphasis is beginning to shift. Projects now in planning stages are expected to complete most of first thinning harvest needed in stands that were established after Hurricane Hugo.

Age Class Distribution

When the current land management plan was written, the Forest had an overabundance of very young forest due to Hurricane Hugo. That event is 23 years in the past, and young forest habitats are now scarce. These young age classes provide habitat that is important to a number of wildlife species; make the forest more resilient to disturbance events, insects and pathogens; and provide a sustained flow of habitats over time. Young age classes of forest (age 0 to 20) present when Hurricane Hugo hit the Forest were largely responsible for sustaining the flow of forest products from the Francis Marion for the next 10 to 15 years after salvage harvest was over, though at reduced levels. While there are younger age trees in the understory of many fire-maintained stands, the age of main stand canopies remains as shown. The acreage of age 1 to 10 stands is 0.1 percent of the Forest. The acreage of age 1 to 20 stands is approximately 3 percent of the Forest.

Figure 8-2 shows the current age class distribution for the Forest.

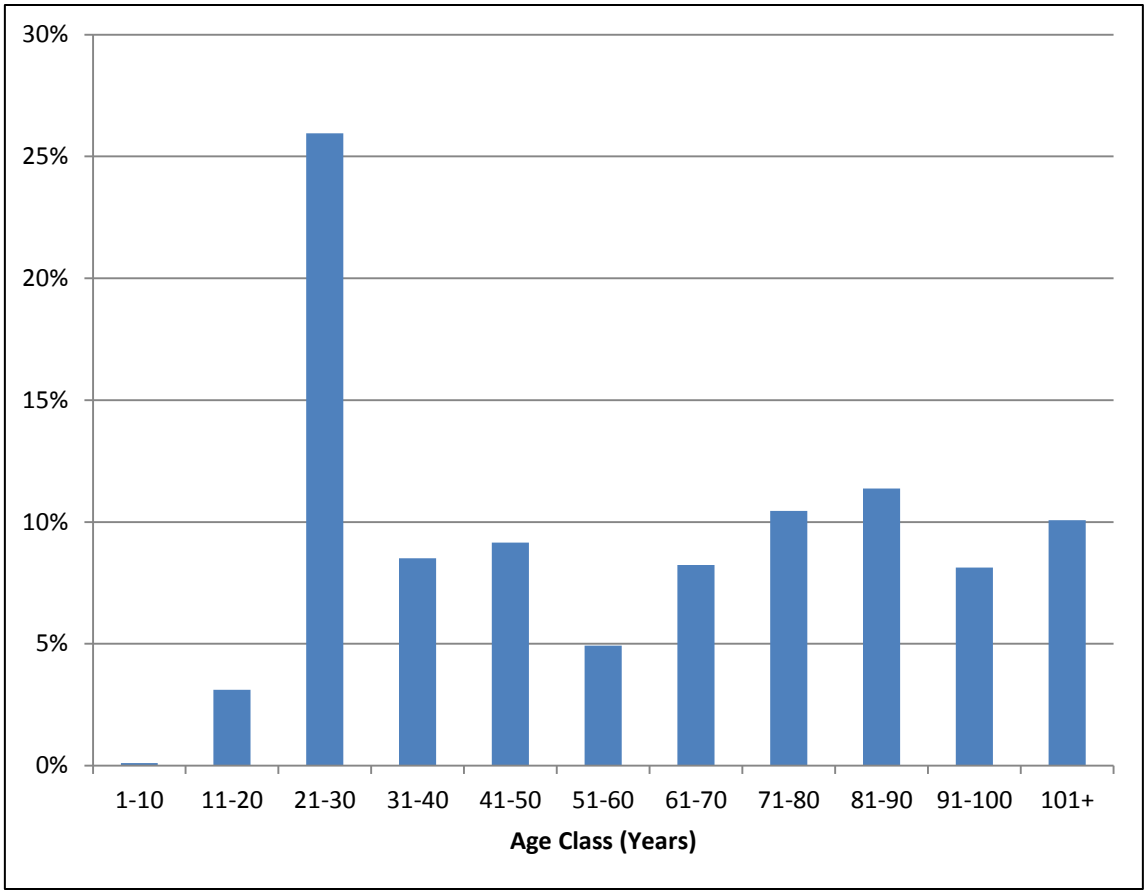


Figure 8-2. Age class distribution for the Francis Marion National Forest, April 2013

Other Forest Products

Firewood is the primary non-timber product for which the Forest has issued permits in recent years. The quantity of the permits has been minor and not significant. Biomass is considered a timber product, and is addressed under energy resources. At present, almost all stands on the Forest have grown into larger size, more valuable products than biomass. Approximately 10 to 15 permits per year are issued for botanical products. Many of these are issued to researchers. Some are issued to individuals, but none of these are commercial, and they are all for small quantities. Permits for animals are not issued by the Forest. Direct taking of animals is a management responsibility of the State.

There is significant commercial demand for pine straw, which is used extensively for landscaping. The Forest ceased issuing these permits in 2007 because they were widely abused and difficult to administer. Illegal raking of pine straw occurs on the Forest.

8.4.1.3 Current Condition and Trends

- Since the current plan was signed there has been a very large increase in timber inventory, as would be expected. Examination of the figures indicates that harvest levels are easily sustainable.
- Long-term timber demand is expected to remain steady or increase.
- The value of harvests from the Forest should increase due to the increasing size of trees harvested and due to an improving economy.

- Species composition of the Forest has changed. There is significantly less loblolly pine and significantly more bottomland hardwood and mixed pine-hardwood.
- The age class distribution has shifted with time. The amount of early successional forest age 0 to 10 is very low, only about 0.1 percent of the Forest.
- Related to the previous item, the need for first commercial thinning harvests is expected to decrease significantly after the next several years.

8.4.1.4 Information Needs

None noted.

8.5 Range

8.5.1.1 Preliminary Findings

There are no current or planned range allotments or allocations on the Forest. The 1996 FEIS states that grazing ceased on the Forest in 1970.

8.5.1.2 Existing Information

The Francis Marion has no range or grazing activity at the present time. There is evidence of past permitted and free-range activity. Grazing stopped in 1970 as stated in the 1996 FEIS. With respect to National Forest management, range allotments are an acceptable practice on national forests predominantly in the western United States. The authority of the Forest Service to regulate specific grazing allotments and operations varies with each Forest.

There have been no special use requests by interested parties since 2005 to use the Forest for grazing or to designate allotments. However, there has been some preliminary conversation to consider a range management plan to aid in rough reduction, mid-story reduction, and understory vegetative control. This would support overall fire suppression efforts, wildlife habitat management for specific species, and the management of longleaf pine ecosystems in the Forest. It could also contribute to the control of nonnative invasive species.

8.5.1.3 Current Condition and Trends

The potential to use grazing to reduce fuel loading is being reviewed.

8.5.1.4 Information Needs

None noted.

8.6 Watershed

8.6.1.1 Preliminary Findings

1. The surface water and groundwater quantities needed for biological, social, and physical resource needs (consumptive and non-consumptive) on the Francis Marion have not been determined and documented. The amount of past hydrologic modifications complicates analysis because there could be water uses that continue to function to the benefit or detriment of resources. Because of uncertainty and lack of information, it may be difficult to address surface and groundwater uses and withdrawal proposals. In addition, this type information is needed to support water rights. The implications from LiDAR suggest that the streams have been highly affected in the past and there is

uncertainty as to the role that these modifications have in withdrawing water from the streams, affecting baseflow amounts and whether they are consistent with environmental flows needed for aquatic organisms and other stream functions (Hansen et al. 2013; Trettin et al. 2008; Cardno Entrix 2012).

2. Viable surface and subsurface water sources will be needed in the extended analysis area including areas of urban expansion and development. Water is a national forest resource. Water use proposals from external parties to use waters from national forest lands or use water from non-national forest lands that may affect other national forest resources are not necessarily eminent, but any proposals for water withdrawals will in most instances need integrated review and a better understanding of the reliance of natural resources on water.
3. Offsite water uses can have significant impacts to national forest resources. In the past, dams, diversions, dredging canals, ditches, dikes and other activities were installed with little consideration as to the effects or the potential for mitigation. The understanding of effects associated with modifying hydrology is now better known. On occasion, past and ongoing actions of major structures will be reevaluated (e.g., FERC relicensing, storm damage assessments, channel dredging). Increased attention may be needed to consider the extent of impacts and potential for mitigation.
4. In reading several of the historic documents, it is apparent that portions if not all of the area was initially granted in large tracts from the King of England, also called Crown Lands. However the wording associated with these grants may have been lost over time in the title records. The presence and wording in these grants can be important in determining water rights, jurisdiction, and ownership issues. The state is unlikely to recognize Crown Lands as any different from other lands unless the specifics of those grants are researched and presented.

8.6.1.2 Existing Information

Water use is obviously important in South Carolina, with about 482,000 people in Berkeley and Charleston counties (Figure 8-3).

Most public supply-water uses are from surface water; 334,000 and 81,000 are served from groundwater sources in Berkeley and Charleston counties, respectively. Self-supplied domestic uses are from groundwater sources, serving another 67,000. The SCDNR water assessment (2009) indicated that availability of ground water in the Coastal Plain greatly exceeds the availability found in the Blue Ridge and Piedmont. Six major aquifers are contained in a clay, sand, and limestone wedge that thickens from a feather edge at the fall line to 4,000 feet at the southern end of the State. Well yields are adequate to abundant for supplying domestic and light-commercial uses nearly everywhere.

Water quality in South Carolina is generally good, and most of the State's water is suitable for public-supply, industrial, and irrigation use. Aquatic life is supported in most of the State's lakes, estuaries, and rivers. Recreational use is supported in nearly all of the lakes and estuaries and a majority of the rivers. Groundwater typically needs no treatment, although chlorination is required of public supply systems.

The greatest use of water in South Carolina goes toward the generation of electricity. Instream water use by hydroelectric power plants in Berkeley County was 557 Mgal/day or 79 percent of the 704 Mgal/day identified as being used within the two-county total. Uses of water for

Charleston and Berkeley counties as of 2005 are presented in the table below (USGS 2005). This area is in an industrializing, developing and high population growth area, and substantial changes have occurred in these areas since 1996. This forecast suggests increased demand for water, but includes uncertainty as to how these demands may affect the Francis Marion.

One of the most significant changes in water use during the last two decades has been the conversion from groundwater sources to surface-water sources by many Coastal Plain communities. This trend is expected to continue to help limit or reduce groundwater withdrawals as they may influence salt water intrusion or locally exasperate the effects of sea-level rise.

The Francis Marion needs sufficient water to maintain, conserve, and protect resources and support the administrative responsibilities that go with land ownership and management.

The specific quantities of water needed to manage and maintain individual circumstances, species, and ecosystems are not well documented or have not been analyzed in detail. A variety of procedures can be used to determine these water quantities, ranging from analyzing records of water use to evaluating environmental flows needed (Cardno Entrix 2012). A general assessment indicates that outside of the national forest, there is a need for suitable surface and groundwater sources for both human consumptive and non-consumptive uses as suggested in Figure 8-3. This table does not address other needs for water such as environmental flows to maintain aquatic ecosystems and species viability.

Data Element	Charleston Co	Berkeley Co	Total
Total population of county, in thousands	330.368	151.673	482.041
Public Supply, population served by groundwater, in thousands	74.852	6.323	81.175
Public Supply, population served by surface water, in thousands	210.337	123.783	334.120
Public Supply, groundwater withdrawals, fresh, in Mgal/d	7.05	0.71	7.760
Public Supply, surface-water withdrawals, fresh, in Mgal/d	76.39	13.88	90.270
Public Supply, total withdrawals, fresh, in Mgal/d	83.44	14.59	98.030
Domestic, self-supplied population, in thousands	45.179	21.567	66.746
Domestic, self-supplied groundwater withdrawals, fresh, in Mgal/d	4.52	2.16	6.680
Domestic, self-supplied surface-water withdrawals, fresh, in Mgal/d	0.00	0.00	0.000
Domestic, deliveries from Public Supply, in Mgal/d	28.52	13.01	41.530
Domestic, total use (withdrawals + deliveries)	33.04	15.17	48.210
Industrial, self-supplied groundwater withdrawals, fresh, in Mgal/d	0.12	3.29	3.410
Industrial, self-supplied surface-water withdrawals, total, in Mgal/d	24.30	8.52	32.820
Industrial, self-supplied total withdrawals, fresh, in Mgal/d	24.42	11.81	36.230
Irrigation, groundwater withdrawals, fresh, in Mgal/d	1.95	0.07	2.020
Irrigation, surface-water withdrawals, fresh, in Mgal/d	0.34	3.04	3.380
Irrigation, total withdrawals, fresh, in Mgal/d	2.29	3.11	5.400
Irrigation, acres irrigated, sprinkler, in thousands	1.86	0.49	2.350
Irrigation, acres irrigated, microirrigation, in thousands	0.95	0.00	0.950
Irrigation, acres irrigated, total, in thousands	2.81	0.49	3.300
Irrigation-Crop, groundwater withdrawals, fresh, in Mgal/d	0.00	0.00	0.000
Irrigation-Crop, surface-water withdrawals, fresh, in Mgal/d	0.07	3.04	3.110
Irrigation-Crop, total withdrawals, fresh, in Mgal/d	0.07	3.04	3.110
Irrigation-Crop, acres irrigated, microirrigation, in thousands	0.95	0.00	0.950
Irrigation-Golf, groundwater withdrawals, fresh, in Mgal/d	1.95	0.07	2.020
Irrigation-Golf, surface-water withdrawals, fresh, in Mgal/d	0.27	0.00	0.270
Irrigation-Golf, total withdrawals, fresh, in Mgal/d	2.22	0.07	2.290
Irrigation-Golf, acres irrigated, sprinkler, in thousands	1.86	0.49	2.350
Irrigation-Golf, acres irrigated, total, in thousands	1.86	0.49	2.350
Livestock, groundwater withdrawals, fresh, in Mgal/d	0.04	0.05	0.090
Livestock, surface-water withdrawals, fresh, in Mgal/d	0.00	0.00	0.000
Aquaculture, groundwater withdrawals, fresh, in Mgal/d	0.00	0.00	0.000
Aquaculture, surface-water withdrawals, fresh, in Mgal/d	0.00	0.27	0.270
Mining, total withdrawals, total (fresh+saline), in Mgal/d	0.00	0.00	0.000
Thermoelectric, groundwater withdrawals, fresh, in Mgal/d	0.00	0.03	0.030
Thermoelectric, groundwater withdrawals, total, in Mgal/d	0.00	0.03	0.030
Thermoelectric, surface-water withdrawals, fresh, in Mgal/d	0.00	557.30	557.300
Thermoelectric, surface-water withdrawals, total, in Mgal/d	0.00	557.30	557.300
Thermoelectric, total withdrawals, fresh, in Mgal/d	0.00	557.33	557.330
Thermoelectric, total withdrawals, total (fresh+saline), in Mgal/d	0.00	557.33	557.330
Thermoelectric, power generated, in gigawatt-hours	0.00	14905.12	14905.120
Thermoelectric once-through, groundwater withdrawals, fresh, in Mgal/d	0.00	0.03	0.030
Thermoelectric once-through, surface-water withdrawals, fresh, in Mgal/d	0.00	557.30	557.300
Thermoelectric once-through, total withdrawals, fresh, in Mgal/d	0.00	557.33	557.330
Thermoelectric once-through, power generated, in gigawatt-hours	0.00	14905.12	14905.120
Thermoelectric recirculation, total withdrawals, total (fresh+saline), in Mgal/d	0.00	0.00	0.000
Thermoelectric recirculation, power generated, in gigawatt-hours	0.00	0.00	0.000
Total groundwater withdrawals, fresh, in Mgal/d	13.68	6.31	19.990
Total surface-water withdrawals, fresh, in Mgal/d	101.03	583.01	684.040
Total surface-water withdrawals, total (fresh+saline), in Mgal/d	101.03	583.01	684.040
Total withdrawals, fresh, in Mgal/d	114.71	589.32	704.030
Note: Data came from a national data base on water use in 2005. There was no saline water uses listed.			
Numerous categories were removed as there was no water uses in either county or the total was the same as the data presented.			

Figure 8-3. Uses of water for Charleston and Berkeley counties as of 2005

Source: USGS (2004).

Water Rights

In the eastern states, landowners have certain water rights associated with riparian areas and streams flowing through their property under old English common law that have been accepted for centuries. Use of water under the riparian right must recognize downstream uses. South Carolina does not operate under a pure riparian right system, but requires a permit for larger water uses (e.g., 3 million gallons of surface water in any month). Some uses (e.g., wildlife habitat management and emergency needs), however, are exempt from this requirement. More specific detail can be found in the following South Carolina State Regulations:

- Surface water: South Carolina Code of Law Section 49-4-10
- Senate Bill 452: South Carolina Surface Water Withdrawal
- Permitting, Use, and Reporting Act of 2010
- Groundwater: South Carolina Code of Law Section 49-5-10

The Francis Marion National Forest has both consumptive and non-consumptive needs. The consumptive withdrawals of water associated with Forest uses are not believed to be of the magnitude requiring a permit or the activities are exempted from permitting. Further checking may be needed to ensure this.

Certain water rights may eventually have to be documented to protect the National Forest needs against competing outside uses or activities. Water rights can sometimes be justified based on original land grants, deeds, and riparian ownership records. The State has been aware of and has recognized instream needs and has made efforts to provide some relief with minimum instream flow requirements (South Carolina Code of Regulations 2010). However, additional analysis should be performed to determine the environmental flows needed to sustain water-dependent ecosystems on Forest Service lands. Laws and regulations that apply to Crown Lands, Federal and national forest lands and resources, and their management are also a basis or justification upon which to claim water rights (Hansen et al. 1990). Examples of Federal laws which contain water-based management direction include the Organic Administration Act of 1897, Weeks Law of 1911, Clarke-McNary Act of 1924, Bankhead-Jones Farm Tenant Act of 1937, McIntire-Stennis Act of 1962, and National Forest Mangement Act of 1976. If national forest waters and associated resources are declining or appear to become vulnerable from State or local policies or adjacent activities, further exploration of water law and rights may be appropriate. Monitoring ecological trends associated with the water demands for existing as well as proposed activities within and adjacent to the national forest resources may be appropriate.

Administrative needs include those waters needed to supply office buildings, fire control, waterfowl, wildlife, recreation and other developments. Non-consumptive needs for water include environmental flows for fish and other aquatic organisms and for other water-dependent ecosystems such as pocosins, wetlands, bogs, and springs. Non-consumptive needs also include water quantities needed for channel maintenance flows, recreational flows, boating access and navigation flows, ecological flows to maintain species, sufficient freshwater to maintain balance with tidal influences, and flows needed to protect the scenic integrity of designated sites. Considerations relative to legacy hydrologic modification may complicate the water use considerations as the flow pattern has been extensively altered with effects not fully known.

The timing and type of land ownership may play a role in determining water rights. The presence of lands initially granted to individuals from the King of England (sometimes called Crown Lands) may support additional claims to water rights since ownership of the land was transferred directly from the King, rather than through the State. Crown Lands without special

grants to tidal lands or waters may still support water claims based on Federal laws that precede State regulations. It is known that portions of the Francis Marion National Forest were granted Crown Lands. However, without extensive title searches, the extent of the grants as well as the wording was often not included in the title transference documents.

Unless specifically granted, tidal lands and waters are typically owned and managed by the State. However, a tract may contain embedded tidal lands and waters under State jurisdiction and regulation, managed for the public good. These tidal areas are typically estimated in extent on land titles and are subject to the normal variation in the tides over time. The assumption is that water and land in these tidal areas are to be considered under State authority unless further title searches indicate otherwise. However, it has become obvious that what is accepted as public good by the State has evolved with time. Passage of relatively permissive uses to drain or modify the tidal influence of these lands by the State Legislature in 1911, which continued to be approved in every decade until 1962, further complicates this situation. For example, these were some of the general provisions in the South Carolina Code of Laws, Title 49, chapter 17 of the Drainage or Levee Districts under 1911 Act:

> **SECTION 49 17 10.** Legislative declaration of public interest.
>
> It is hereby declared that the drainage of swamps, the drainage of surface water from agricultural lands and the reclamation of tidal marshes shall be considered a public benefit and conducive to the public health, convenience, utility and welfare.
>
> HISTORY: 1962 Code Section 18 201; 1952 Code Section 18 201; 1942 Code Section 6096; 1932 Code Section 6096; Civ. C. '22 Section 3150; Civ. C. '12 Section 2196; 1911 (27) 92; 1913 (28) 16; 1914 (28) 455, 460, 514; 1916 (29) 748; 1920 (31) 804.
>
> **SECTION 49 17 20.** Chapter to be liberally construed.
>
> The provisions of this chapter shall be liberally construed to promote the leveeing, ditching, draining and reclamation of wet and overflowed lands.

Since this was found on the current South Carolina Code of Laws website at http://www.scstatehouse.gov/code/title49.php, and there was no mention that it had been repealed, portions of these regulations may still be active. These regulations were reapproved each decade until 1972, when it appears that the concerns for tidal and freshwater wetland drainage and habitats probably weighed heavily in the legislature's decision to not reauthorize. Obviously then, the State has from time to time granted uses and even supported limiting tidal extent or conversion of the tidal marsh for private uses. The State continues to evaluate and grant or permit specific uses of these lands or access to tidal water to tract landowners, such as boardwalks and docks for access to tidal waters. However, many of the activities that were once acceptable are no longer allowed, but modifications that were made legally under former regulations are apparently still authorized as long as consistent with appropriate responsibilities to maintain. If the diking, drainage, or other improvements are not maintained, it is likely they still may function to some degree, but may go back into their former management category. However, developments by human activity in tidal lands do not change ownership (SC DHEC Coastal legal advice).

South Carolina remains under the common law riparian right system of water use that allows landowners to use water as long as it does not infringe on other users or beneficial uses downstream. However, as mentioned, certain larger uses of surface and groundwater (i.e., greater than 3 million gallons in any month) require permits. A few exemptions exist such as for wildlife habitat management.

After Hurricane Hugo, it was obvious that most of the old drainage ditches within the National Forest and adjacent areas had not been maintained for many years. It is not known which of the past drainage modifications are still being maintained by counties or communities. It is believed that the County Clerk of Court as authorized in the regulations associated with the drainage districts maintain these records.

SCDHEC and SCDNR are the water regulatory agencies within South Carolina, and the regulation of water is a complex subject area that must consider the many components mentioned as well as court decisions of record. The Francis Marion National Forest intends to be consistent with Federal law and the South Carolina Code of Laws. If at some time, South Carolina moves from a riparian right state with large uses permitted to another form of water management, added measures to evaluate and determine water needs, uses and legal justifications may be considered if circumstances are unfavorable to national forest resources. However, at this time, the Francis Marion National Forest as any other landowner with water needs must be aware of adjacent uses that may modify or alter resources on the national forest. It must be also recognized that most of these adjacent uses or potential effects are not well known. Fortunately, most of the small to moderate size streams contained on the Francis Marion National Forest include much of the headwater areas. So perhaps in many instances, the main concern may be outside water uses which would limit the normal migration and movement of aquatic species, or which would be detrimental to water-dependent ecosytems. The current South Carolina instream flow policy presented in a following section contains some protection to limit effects.

8.6.1.3 Current Condition and Trends

Consumptive Uses

Administrative uses include potable water supplies for administrative buildings and recreation sites, and water for fire control. Preliminary estimates of these uses were discussed by Bill Hansen, Mark Danaher, and Bruce Liles.

Wildlife annual needs in cooperation with SCDNR are estimated to include a total of 2032-acre feet of water including Tibwin (90 acres × 6 feet = 640 acre feet), greentree reservoirs (217 acres × 6 feet = 1,302 acre feet), and wildlife/railroad fire control dam (15 acres × 6 feet = 90 acre feet).

There are currently 19 wells on the official system within the Francis Marion National Forest. Five of these are not being used at this time and are currently considered excess. Four wells are inactive at this time. Ten wells are actively being used. There are five administrative wells on the Forest that currently supply water to recreational facilities. There are two wells used at Tibwin Plantation site. There is one flowing (artesian) well available for public and emergency use. The administrative sites with current use wells include the Seed Orchard, Helibase and Work Center. From water sources outside of the Francis Marion National Forest, there are two recreational facilities and one at the District Office that are served by municipal water sources. The water quantities needed for consumptive drinking and associated water uses are not currently available at this time.

Emergency firefighting sometimes uses water to suppress wildfires. Sources of water for dip spots may include Little Hellhole Lake. Other sources of water outside of the National Forest such as from nearby fire stations are sometimes used. The amount of use has not been estimated or addressed at this time.

Specific requests for water uses outside of the National Forest are infrequent, but there is potential for requests in the future as more development occurs. Historic demands and changes have primarily been associated with the Santee Cooper Project, which dams and diverts water from the Santee River to the Cooper River for power generation, recreation, and other uses. Most of the surface water withdrawn in Berkeley County was for thermoelectric use, with the 557 Mgal/day used to generate about 15,000 gigawatt-hours of electricity. These are considered consumptive uses since the water is diverted from the Santee River. This demand has modified the river function with resultant effects to anadromous fish, migratory fish, channel modifications due to lack of channel maintenance flow, rapid changes in flow, salt water influx from the Santee Delta to Jamestown, South Carolina, and several tributary areas on the Francis Marion National Forest including Wambaw Creek Wilderness and Echaw Creek, stream temperature and other modifications to water quantity and quality.

From the large number of small dikes, ditches, and diversions within stream channels, riparian areas and wetland, there have been in the past a number of undocumented water uses made for various reasons. Some of these are still probably functional at modifying flow to either drain or flood, contain freshwater or restrict tidal action (Berkeley County et al. 1963; Hansen et al. 2013).

Non-consumptive Water Uses

Some water uses do not actually consume the water from the channel. Instream flow needs may include biological needs (fish, aquatic life, spawning periods of high need), human needs, (recreational uses such as boating, swimming, scenic), and abiotic needs such as channel maintenance such as enough flow to maintain channel capacity, function and acceptable water quality) (Cardno Entrix 2012). However, channel maintenance flows of bankfull flow is often recognized as needed every year or two to maintain the channel form and prevent excessive encroachment by vegetation into the channel. Bankfull flow is typically the storm that occurs on average every 1.25 to 1.5 years that causes the channel to fill to capacity and spill onto the floodplain. Due to the amount of drainage and channel modification that was installed to drain the land and probably reduce flooding frequency, the bankfull flow may be best determined for reference reaches that have not been modified. The amount of flow needed to maintain these uses is variable for the circumstance, and special analysis instream analysis tools have been developed to help address these needs.

South Carolina Code of Regulations contains an instream flow policy. However, the Forest Service will need to analyze whether the State's policy is adequate for sustaining ecosystems on Forest Service lands:

> **South Carolina Instream Flow Policy:** Minimum instream flow is defined in SB 452 as 40 percent of the mean annual daily flow for January through April; 30 percent of the mean annual daily flow for May, June, and December; and 20 percent of the mean annual daily flow for July through November (South Carolina Code of Regulations, 2010, implemented January 1, 2011).

It is preferable to conduct an instream flow analysis prior to reaching a situation of excessive water demand, which can result in over withdrawals, resource damage and potential for civil suits. Instream flows have not been sufficiently evaluated on the Francis Marion National Forest to determine the actual needs. However, instream flow analysis was conducted for the Santee River during the initial stages of the Santee Cooper relicensing project, which is currently delayed to address specific issues. However, their instream flow work was conducted on the effected portions of the Santee and Cooper Rivers and not adjacent tributaries.

Past hydrological modifications probably would complicate instream flow analysis in that their presence has modified the flow and habitat in various ways. Some channelization and ditches were installed to drain the landscape and have probably reduced perennial flow, expanded the stream network, and reduced the storage and retention of water. In other circumstances, dikes were installed to limit tidal entry or to store freshwater for rice culture management unless needed releases to reduce the effects of wind driven tides during some storm events.

Tidal Interactions and Changes Due to Uses

There may be some use of tidal water to maintain habitat in one of the Tibwin dikes with brackish water. However, the preferred management is freshwater. There are not any other known intentional consumptive uses of the tidal waters. As mentioned, there were legacy modifications made to limit tidal extent or function, most of which have not been evaluated. The freshwater (or brackish) dikes at Tibwin are important structures for coastal water bird conservation that were present when the tracts were acquired.

The potential for non-consumptive uses include recreational activities for boating, canoeing, or kayaking or other water-based sports at several sites including Buck Hall, Tibwin, Awendaw Creek, Wambaw Creek, Chicken Creek, Huger Creek and Santee River (McConnells Landing). Additional discussion on this use is in section 9 "Assessing Recreation Settings, Opportunities, Access and Scenic Character." There are other remote tidal and river access points that may be known to the Forest or public. Some remote areas are not official access points, but may be reached on foot. Some in-channel structures or dikes were installed to limit the tidal influence and the extent of their continuing function is often not known.

There are no known municipal watersheds on the National Forest. A minimum of 500 feet is required adjacent to source water protection areas (SWPA) including wells for the Wambaw and Witherbee work centers. The artesian public water drinking source at Huger Boat Landing probably needs to be considered a SWPA. Information from DHEC is being sought to see if there are other SWPAs that need to be considered [http://www.scdhec.gov/environment/water/srcewtrreports.htm].

Adjacent water uses associated with hydrological modifications of Lake Moultrie, with diversion and rediversion of water, may have some potential as sources for municipal and community water uses. The specifics of this potential are likely addressed in the Santee Cooper Project files. The flow modifications of the Santee Cooper Project are primarily used for power generation, but the transfer to augment the Cooper River system is an important element for the Charleston area for port activity, navigation, and pollution abatement. The rediversion canal at the St. Stephen Dam helps to restrict sediment diverted to the Cooper River through the Jeffreys Dam and locks and return some sediment and flow back into the Santee River system with some elevation advantage to generate more power than capable at the Wilson Dam. The main impacts to the Santee River system, in addition to the impact on aquatic migration, is the low flow releases are much lower than historic low flow, resulting in periodic salt water entry into the Santee River to Jamestown, and adjacent tributaries, which were all formerly a fresh water system.

Special Use Needs for Water

Outfitters and guides provide services that are dependent on water. Trips include tidal and inland streams and rivers using canoes and kayaks, and boat trips on the Intracoastal Waterway that access the nearby barrier islands. Buck Hall Recreation site is an important navigational access point. Since these would be non-consumptive uses in primarily waters with tidal influence, the

question of minimum flows required by the State may or may not be sufficient flow for navigation use. Substantial diurnal fluctuation may be inconvenient, but common in tidal waters and still be within the bounds of acceptability.

8.6.1.4 Information Needs

The Francis Marion National Forest needs to better quantify and document water use needs. Many of the amounts included were just raw estimates, not based on field data collection, physical site, or activity review.

9 Assessing Recreation Settings, Opportunities, Access and Scenic Character

9.1.1.1 Preliminary Findings

Preliminary findings associated with recreation include:

1. National goals for recreation management have changed since the 1996 Revised Land and Resource Management Plan.
2. Due to steady population growth and urbanization of surrounding areas, intensity of Forest recreation use is expected to increase over the next 15 years.
3. Recreation on the Forest contributes to the physical, mental, and spiritual health of people.
4. Visitors are generally satisfied with the way outdoor recreation settings are managed on the Francis Marion; however, a few exceptions warrant additional attention by recreation managers.
5. The Forest recreation budget is trending downward and fewer resources are available to maintain existing recreational facilities or to develop new ones.
6. Forest recreational visitors, while primarily local, do not reflect the racial nor gender composition of the State or counties in which it lies.
7. There are significant differences between local and nonlocal preferences for recreation settings, opportunities, facilities and services found on the Forest.
8. As one of the largest land bases for outdoor recreation in the State of South Carolina, the Francis Marion is uniquely suited to provide certain types of recreation opportunities that cannot be found elsewhere.
9. The Francis Marion National Forest is rarely recognized in State and local tourism planning, which focuses primarily on golf and beach resorts, and historic sites.
10. Recreation use of the Forest provided through special use permit has increased, 425 percent in 3 years. Demand for hiking/running events has increased most significantly.
11. Visitation to the Sewee Visitor Center has declined since 2008.
12. The Forest collaborates with many recreation-focused volunteer organizations and partners.
13. Some recreation sites are not being managed compatibly with the ROS (recreation opportunity spectrum) objectives of the larger area and some sites and not being managed compatibly with the management area prescriptions.
14. The 1996 Forest plan makes no mention of broader recreational planning efforts in which the Forest contributes, such as the Berkeley County Blueways paddling trail system, the Palmetto Trail, and the Southeast Coast Saltwater Paddling Trail. The 1996

Forest plan does not provide guidance on coordination of such recreation opportunities which span beyond Forest boundaries and require multi-management.

15. To date, the Forest provides 174 miles of Forest Service managed trail opportunities. 108 percent of the objective has been met to increase the trail system to 160 miles.

16. To date, the Forest provides recreational facilities with a total designed capacity of 1,414 PAOTs (people at one time). About 64 percent of the short-term PAOT objective and 54 percent of the long-term objective has been met.

17. An inventory update is needed to identify the appropriate ROS class for the Wambaw Creek Wilderness which allows for motorized boating; this is inconsistent with the current primitive setting objectives.

18. Only 13 percent of the Forest is managed as primitive or semi-primitive, despite its unique position to provide for these settings.

19. Providing a "range" or "diversity" of recreational opportunities is emphasized throughout the 1996 Forest plan as a Forest goal, desired future condition, and Forest standard. Conversely, the plan does not identify the distinctive role of the Forest to provide recreation or where management emphasis should be placed to achieve a sustainable recreation program.

20. Not all existing recreation uses and activities on the Forest are compatible.

21. There are unmanaged or illegal activities or uses, such as illegal off-trail OHV use, that impacts natural or cultural resources.

9.1.1.2 Overview

Planning Rule and Context

Recreation contributes to social and economic sustainability and provides opportunities to connect people with nature. The focus of the assessment for recreation is to identify and evaluate information about recreation settings and the uses, trends, and sustainability of recreation opportunities in the plan area; recreational preferences of the public; recreational access; and scenic character.

The 2012 planning rule directs that forest plans must provide for sustainable recreation (219.10(b))1)(i). The rule defines this as "The set of recreation settings and opportunities on the National Forest System that is ecologically, economically, and socially sustainable for present and future generations". (219.19) Sustainability is defined as:

> The capability to meet the needs of the present generation without compromising the ability of future generations to meet their needs. For purposes of this part, ''ecological sustainability'' refers to the capability of ecosystems to maintain ecological integrity; ''economic sustainability'' refers to the capability of society to produce and consume or otherwise benefit from goods and services including contributions to jobs and market and nonmarket benefits; and ''social sustainability'' refers to the capability of society to support the network of relationships, traditions, culture, and activities that connect people to the land and to one another (219.19).

National Context and Trends

National goals for recreation management have changed since the 1996 Revised Land and Resource Management Plan. In Connecting People with America's Great Outdoors: A Framework for Sustainable Recreation, the 2010 report addresses the long-term sustainability of outdoor recreation in the USDA Forest Service and sets goals for managing recreation in the future. It concludes:

The benefits to American society that outdoor recreation provides are needed more today than ever before:

- America spends $2 trillion dollars on crisis medical health care. Overweight, obesity, and physical inactivity are major risk factors for chronic diseases such as diabetes, cardiovascular disease, and cancer. Physical activity is an integral part of a healthy lifestyle, and outdoor recreation is the natural solution—a disease prevention solution—and part of the Nation's existing wellness infrastructure.
- The economic base of many communities is shifting as industries consolidate and relocate, and service and experience businesses rely on outdoor recreation for their customers and as quality of life attractions for employees.
- Population growth and land development demand more environmental services from a decreasing and fragmented land base, yet people become less familiar with, and respectful of, natural landscapes and historic sites every year.
- The increasingly urbanized and technology focused American population, including children, is losing touch with the contributions of public lands to the basic resources that affect their lives. Americans sense of place and national identity can be enhanced by experiencing historic sites and landscapes that represent the abundant natural and cultural heritage of the Nation.

At the same time, there are unprecedented challenges to providing quality recreation:

- Demographic shifts and lifestyle changes have greatly affected demand for recreation on national forests and grasslands. With 80 percent of our population living in cities, our country is the most urban it has ever been. For many, the only exposure to the natural environment is what they see on television and computer screens. Others find our existing recreation facilities and programs not in line with their cultural traditions.
- Growth of retiree communities and other population shifts have created population centers close to many public lands. This has resulted in many of our forests being enjoyed as regional and municipal parks adding additional strain on visitor facilities, services, and natural settings.
- The condition of our recreation and heritage assets has steadily diminished, resulting in a ballooning backlog of maintenance needs for recreation facilities, trails, and roads.
- Unmanaged recreation has contributed to degraded recreation settings, damaged heritage sites, unacceptable resource impacts, and conflicts between users.
- National economic conditions and mounting financial demands underscore the inadequacy of traditional funding sources to meet growing needs, yet user fees and private sector involvement to deliver services remain controversial to some.

The USDA Forest Service mission: "To sustain the health, diversity, and productivity of the Nation's forests and grasslands to meet the needs of present and future generations" and the

Agency's vision: "Renewing body and spirit, inspiring passion for the land" produce several guiding principles. The guiding principles for our mission and vision are:

- **Connecting people with their natural and cultural heritage** is a vital thread in the fabric of society. It contributes to the American identity and reminds people of the resources that sustain life: water, soil, food, and fiber. Moreover, recreation is the portal for understanding and caring for natural resources and public lands. It provides opportunities and motivation to advance from fun and attraction, through awareness, education and understanding, to a role of citizen stewardship: one of "giving back" and supporting sustained management of natural resources.
- **Recreational activity in the great outdoors promotes healthy lifestyles.** Combined with good nutrition, it contributes to improved physical, mental, and spiritual health, and a shift away from treating illness toward creating wellness.
- **Sustainability underlies all program decisions.** In order to sustain the benefits of outdoor recreation for present and future generations, the recreation program must address and work toward a sustainable balance among the three spheres of environmental, social, and economic conditions.
- **Community engagement is essential** for creating a sustainable recreation program. Our role is to serve as planners, facilitators, conveners, and collaborators, tapping the enormous energy and creativity of people in communities that care for and benefit from public lands, including both the private and public sectors.
- **National Forests and Grasslands are part of a larger landscape that includes:** other public lands; open spaces at the local, state, and Federal level; tribal lands; working farms and ranches; and towns and cities. Respecting and cultivating the relationships across all lands and communities is necessary to strengthen the health and vitality of each.
- **The recreation program is integrated into the larger agency mission.** By working together with other program areas to integrate program goals and service delivery, we maximize our contribution by connecting programs, people, and landscapes.

The report also states the Forest Service goals toward building on the foundation of the mission, vision, and guiding principles and the Agency will strive to:

- **Provide** a diverse range of quality natural and cultural-resource-based recreation opportunities in partnership with people and communities.
- **Protect** the natural, cultural, and scenic environment for present and future generations to enjoy.
- **Partner** with public and private recreation benefit providers that together we meet public needs and expectations.
- **Perform** and plan by implementing systems and processes to ensure: effective decisions, sound investments, and accountability; collaborative approaches to integrated solutions across the landscape; and enhanced professionalism of our workforce.

The following focus areas comprise some of the actions that will help the Agency achieve sustainable recreation programs on every national forest:

- **Restore and adapt recreation settings**

  - Through integrated research, analysis, planning, and quality design, restore the condition and function of our recreation facilities and settings, expanding and adapting them to reflect the diversity of cultures, abilities, family structure, and activities in our ever-changing society.
  - Resolve unmanaged recreation through a planned and properly designed network of roads, trails, and facilities, combined with educated citizen stewardship and partnerships, as well as field presence to provide quality recreation experiences while reducing the impacts of visitor use on the landscape.
- **Implement "green" operations**
  - The recreation and tourism program will reduce its environmental footprint and serve as a model for our visitors and other providers by incorporating sustainable travel industry best practices; "green technology" for facility and trail construction; and environmental management systems in all aspects of our operations.
- **Enhance communities**
  - Together with our communities and stakeholders, develop a common vision and define potential roles to sustain the economic and quality of life benefits of recreation and tourism assets within these destinations.
  - Included will be shared infrastructure development, delivery of information, and provision of recreation services that addresses connections of urban areas and rural communities to the scenic attractions, historic places, and recreation opportunities of the national forests and grasslands.
  - Community and state parks, other Federal and tribal lands, and local open space lands will be evaluated for connections with National Forest lands as well as for their own contributions, existing and potential, for meeting the outdoor recreation and tourism demands for the area.
- **Invest in special places**
  - Evaluate areas within the National Forest system that have outstanding recreational, scenic, historic, or other values of high attractiveness for designation and management as special areas.
- **Forge strategic partnerships**
  - Cultivate coalitions of recreation interest groups that will help provide recreational experiences, service activities, and environmental education for youth and adults that promote fitness, appreciation of nature and history, and citizen stewardship.
- **Promote citizen stewardship**
  - Cultivate the energy, enthusiasm, and skills of private and nonprofit sector partners and volunteers to provide services and connect people to the land.
- **Know our visitors, community stakeholders, and other recreation providers**
  - Stay current with demographic shifts, changing values and demands, data sources, new technologies, and management tools.
- **Provide the right information**
  - Invest in consolidating and improving our external recreation information systems with an emphasis on quality, consistency, accessibility and convenience.

- **Develop a sustainable financial foundation**
  - It is unlikely that appropriated funds will ever meet the total program need for providing excellent recreation opportunities while protecting the land. Program delivery will be balanced on a base of appropriated funds through expanded capacity by utilizing user fees, volunteers, private providers, and partners in the nonprofit sector.
  - Proposed new development investments and program improvements will be evaluated along with the capacity to sustain existing ones. The gap between program needs and available resources will be identified along with options for closing the gap.

National outdoor recreation trends are described in Outdoor Recreation Trends and Futures: A Technical Document Supporting the Forest Service 2010 RPA Assessment. This publication presents a national study of outdoor recreation trends as part of the 2010 Renewable Resources Planning Act Assessment by the Forest Service. This national assessment describes the status and trends in outdoor recreation participation across the United States. Tracking these trends is especially important because of the large role outdoor recreation plays in American lifestyles, and because of the large investments and management responsibilities of both the public and private sectors as providers of recreation opportunities.

The report reviews past trends in outdoor recreation participation by Americans, describes in detail current outdoor recreation participation patterns and compares patterns across regional and demographic strata. It also describes recreation activity participation on public and private lands and providing projections of outdoor recreation participation out to the year 2060. There are several trends that are discussed in the report:

- The mix of outdoor activities chosen by Americans and the relative popularity of activities overall have been evolving over the last several decades.
- There is growth in outdoor recreation, including nature-based recreation, even though some traditional activities have been in decline.
- There is growth in the activities of "viewing and photographing nature".
- Different segments of society chose different types and levels of participation in different mixes of outdoor activities.
- Youth do spend time outdoors, and for some, it is substantial.
- Public lands continue to be highly important for the recreation opportunities they offer.
- Visitation to public lands is stable to increasing for some, like National Park Service and Bureau of Land Management lands, visitation shows growth for U.S. Fish and Wildlife refuges and declining use for national forest lands.
- There are many different motivations for why people seek different forms of outdoor recreation and some segments of our society feel more constrained than others.
- Finally, the future trends project that nationally the five activities projected to grow fastest in per capita participation over the next 50 years are developed skiing, undeveloped skiing, challenge activities (caving, rock climbing, mountain biking, etc.), equestrian activities, and motorized water activities. The activities projected to decline include visiting primitive areas, motorized off-road activities, motorized snow activities, hunting, fishing and floating.

Statewide Recreation Context and Trends

In South Carolina, there is a wealth and variety of recreation settings, from the Blue Ridge Mountains and foothills, the rolling Piedmont, Sandhills, broad Coastal Plains, and the coastal barrier islands and expansive beaches of the Atlantic Ocean. The State has multiple entities that provide recreation, national parks, national forests, national wildlife refuges, State and county parks, city and local parks, and private and non-profit lands.

The Statewide Comprehensive Outdoor Recreation Plan (SCORP) is South Carolina's official document regarding outdoor recreation planning. The South Carolina Department of Parks, Recreation & Tourism, as the administrator of the National Park Service's Land and Water Conservation Fund (LWCF) program, must complete/update the plan every 5 years in order to receive LWCF monies. Several other Federal and State grant programs also utilize or reference the SCORP. The SCORP is currently being updated in 2013, for the period of 2013–2017.

Priorities for the upcoming SCORP will be assembled from many sources including various stakeholders and outdoor recreation user groups, colleges and universities, the USDI National Park Service, and citizens from across the State. The SCORP addresses anticipated trends and needs of outdoor recreation while focusing South Carolina on priorities that ensure sustainable results. The initial priorities for the 2103 SCORP include:

- **Promoting healthy lifestyles and communities:** Outdoor recreation, parks, and their associated amenities help keep South Carolinians and their communities fit and healthy. While the connection between health and outdoor recreation seems apparent, public health professionals and outdoor recreation providers have not always coordinated their efforts. South Carolina remains one of the top ten most obese states in the country. In 1996 South Carolina had a combined obesity and overweight rate of 51.4 percent. In 2001 it was 57.4 percent; and now the combined rate is 66.4 percent. Parks help build healthy communities by creating stable neighborhoods and strengthening community development. Outdoor recreation providers have not only the opportunity to impact the overall health of our State, but an obligation.
- **Stewardship of the resource:** Conserving South Carolina's natural resources will be a vital component of outdoor recreation planning for the next decade. The State's "green infrastructure" not only protects the physical characteristics of South Carolina's unique diversity of natural resources, but if utilized correctly, can be a critical building block for communities and sustained economic growth. As South Carolina's population continues to increase, the conservation of the State's natural resources becomes an important component of the successful formula for both sustained economic growth and a quality of life desired by our citizens.
- **Sustained economic benefits:** The economic benefits of outdoor recreation in South Carolina are significant. By utilizing and leveraging the State's outdoor recreation resources and attractions, we can promote tourism and create jobs that contribute millions of dollars to the State's economy. Perhaps the greatest value of parks, recreational lands, and their amenities lies in their ability to attract and keep citizens, entrepreneurs, businesses, and the growing number of retirees who locate for quality of life reasons.

Some additional points to consider from the 2008 SCORP include:

- The State has favorable weather conditions for recreation with an average temperature of 65 and an abundant water supply.

- There are continued population increases. Racial composition will continue to change as growth rates for Hispanic and Asian populations continue to grow faster than the State average.
- The State park system encompasses 47 state parks and over 80,000 acres.
- There are more than 2,793 miles of trails in the State. More than one-fourth (29.1 percent) of these trails are for water activities such as canoeing, rafting, and kayaking. Nearly 541 miles (19.4 percent) are hiking trails and 423.9 miles (15.2 percent) are for hiking and mountain biking. Equestrian trails total 413.3 miles and comprise 14.8 percent of the State's trails.
- Mirroring the State's population growth, the demand for new, updated, and expanded recreational facilities continues to increase. However, funding remains limited and recreational expenditures must be prioritized.
- Travel and tourism is a major economic impact to the State. Outdoor recreation plays an integral, yet largely untapped, role in South Carolina's burgeoning tourist industry.

Even though the SCORP mentions the untapped role that outdoor recreation has, the Francis Marion National Forest is rarely recognized in State and local tourism planning, which focuses primarily on golf and beach resorts, and historic sites.

Local Recreation Context and Trends

National Visitor Use Monitoring. A majority of visitors are "very satisfied" with the overall quality of their recreation experience on the Forest. Monitoring shows that major changes to facilities are not being demanded.

Visitor use monitoring surveys was conducted on the Francis Marion and Sumter National Forests in FY 2008 (and previously in 2002). Additional recreation satisfaction monitoring will be accomplished in 2012. NVUM indicated that there were some areas in user satisfaction that could be improved. The overall satisfaction results showed that almost 79 percent of the people who visited were very satisfied with the overall quality of their recreation experience. Another 16 percent were somewhat satisfied and less than 1 percent expressed any level of dissatisfaction.

- Developed sites and wilderness scores showed that developed facilities, access, and perception of safety all were above the 85 percent national satisfaction target. Access and perception of safety rated higher than 85 percent for undeveloped areas.
- The surveys did show that there are areas that could use improvement, including overnight sites (improve availability of recreation information and adequacy of signage), general forest areas (improve restroom cleanliness, in such areas as trailheads) and wilderness (improve adequacy of signage). The majority of the visiting population is very satisfied with road condition and adequacy of signage Forestwide. Over three-quarters of the visiting population also feel that road condition and adequacy of signage is very important.

Population Growth. Due to steady population growth and urbanization of surrounding areas, intensity of Forest recreation use is expected to increase over the next 15 years.

Data collected during 2008 Forest National Visitor Use Monitoring shows that the Forest receives approximately 430,000 visits per year. This averages to 1,200 visitors per day or 1 visit

for every acre of national forest in a 1-year period. Recreation use is expected to increase given predicted population growth trajectories and land use and development in surrounding counties.

According to the U.S. Census, between 1980 and 2010, the State's population increased by 48 percent, significantly higher than the U.S. average (see section 6 "Social and Economic Assessment"). Additionally, total population within the surrounding eight counties increased by an even greater percentage at 60 percent. The rapid population growth over the last 30 years suggests that this area is highly desirable to current and prospective residents. Population forecasts predict that growth will continue over the next 30 years, as well.

The population of Berkeley County alone grew 88 percent between 1980 and 2010. This is substantiated by the total number of housing units for Berkeley County which more than doubled from 1980 (31,771 units) to 2008 (65,367 units).

Population projections provided by the South Carolina Office of Research and Statistics indicate that, while the rate of population growth will decelerate when compared to decades prior to 1990, steady growth of 5 to 7 percent every 5 years and 10 to 12 percent every 10 years will still be experienced for Berkeley County, as illustrated in Figure 9-2.

Charleston County has also experienced steady population growth. The county's population grew approximately 26 percent between 1980 and 2010. According to the 2008 Charleston County Comprehensive Plan, the county can reasonably expect 85,000 new residents during the span of 2007 through 2020, resulting in a 2020 population of 425,000[9]. Thus, it is also predicted to experience steady population growth into the future, with a predicted population gain of 19 percent over 10 years.

[9] Charleston County Comprehensive Plan Update Plan: adoption date November 18, 2008 by Ordinance No. 1567: Amended December 22, 2009 by Ordinance No. 1622; October 11, 2011 by Ordinance No. 1694; February 23, 2012 by Ordinance No. 1720; and May 8, 2012 by Ordinance No. 1722.

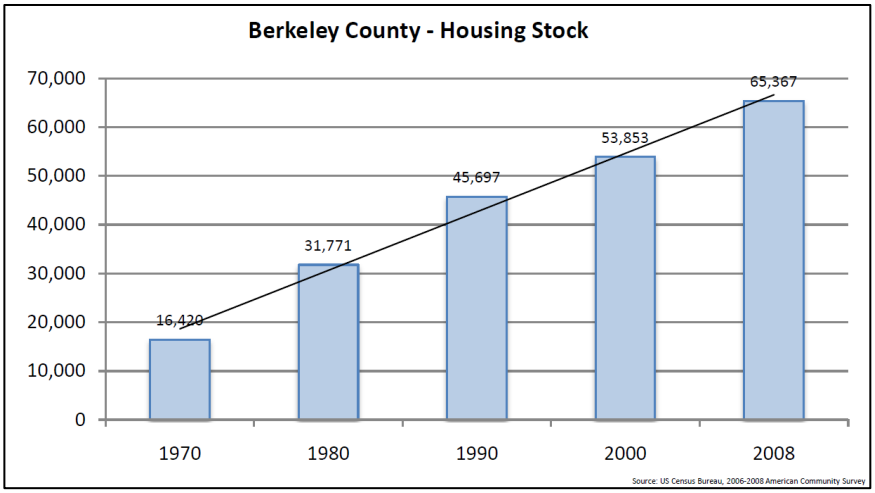


Figure 9-1. Berkeley County housing stock

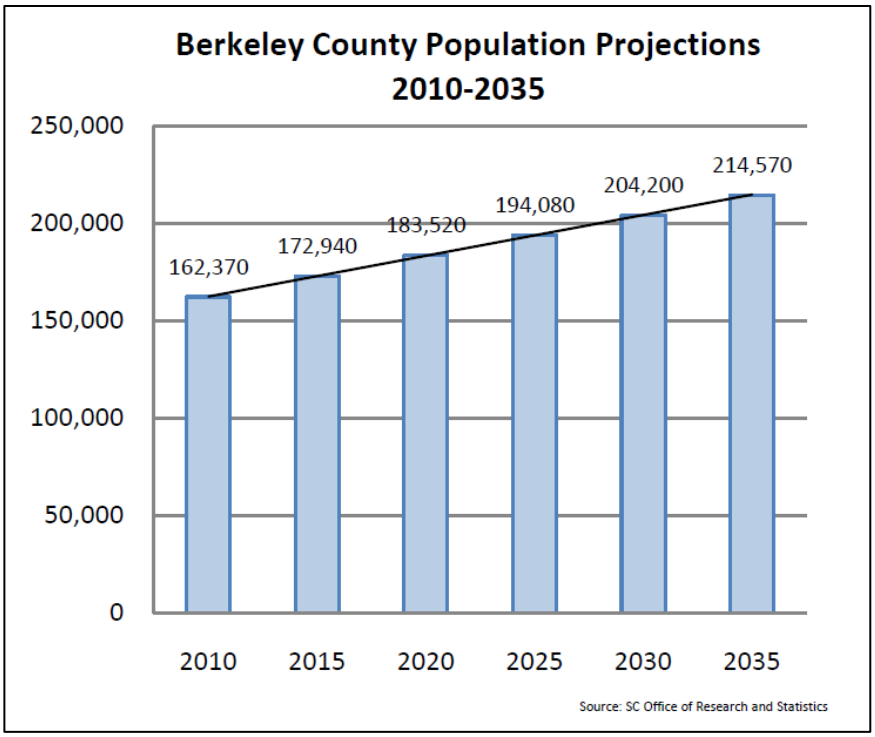


Figure 9-2. Berkeley County population projections

Source: Berkeley County Comprehensive Plan, 2010.

	1970	1980	1990	2000	2007 (Estimated)	2010 (Forecast)	2020 (Forecast)
Total County Population	247,650	276,974	295,039	309,969	339,516	357,127	425,000
Net Change over Previous Decade	31,268	+29,324	+18,065	+14,930	+29,574 (over 2000 population)	+47,158 (over 2000 population)	+67,873 (over 2010 population)
Percent Change over Previous Decade	+14.5%	+11.8%	+6.5%	+5.1%	+9.5% (over 2000 population)	+15% (over 2000 population)	+19% (over 2010 population)

2007 population estimated based on analysis of available recent population estimates
2010 and 2020 population forecasts based on 1.7% annual growth rate
Sources: U.S. Bureau of Census 1970, 1980, 1990, 2000, Miley, Gallo & Associates, LLC (2007)

Figure 9-3. Countywide population trends and estimates (1970–2020)

Land Use & Development. Existing land use maps of Berkeley and Charleston counties show that a large percentage of land is yet undeveloped. In 2008 approximately 70 percent of the land area in the unincorporated Charleston County was either forested or contained wetlands, marsh, and other water features. In Berkeley County 84.2 percent was undeveloped in 2010 (i.e., conserved, vacant, or devoted to agriculture or forestry), and of the remaining 15.8 percent, about half was occupied by single-family homes on parcels up to almost 500 acres in size.

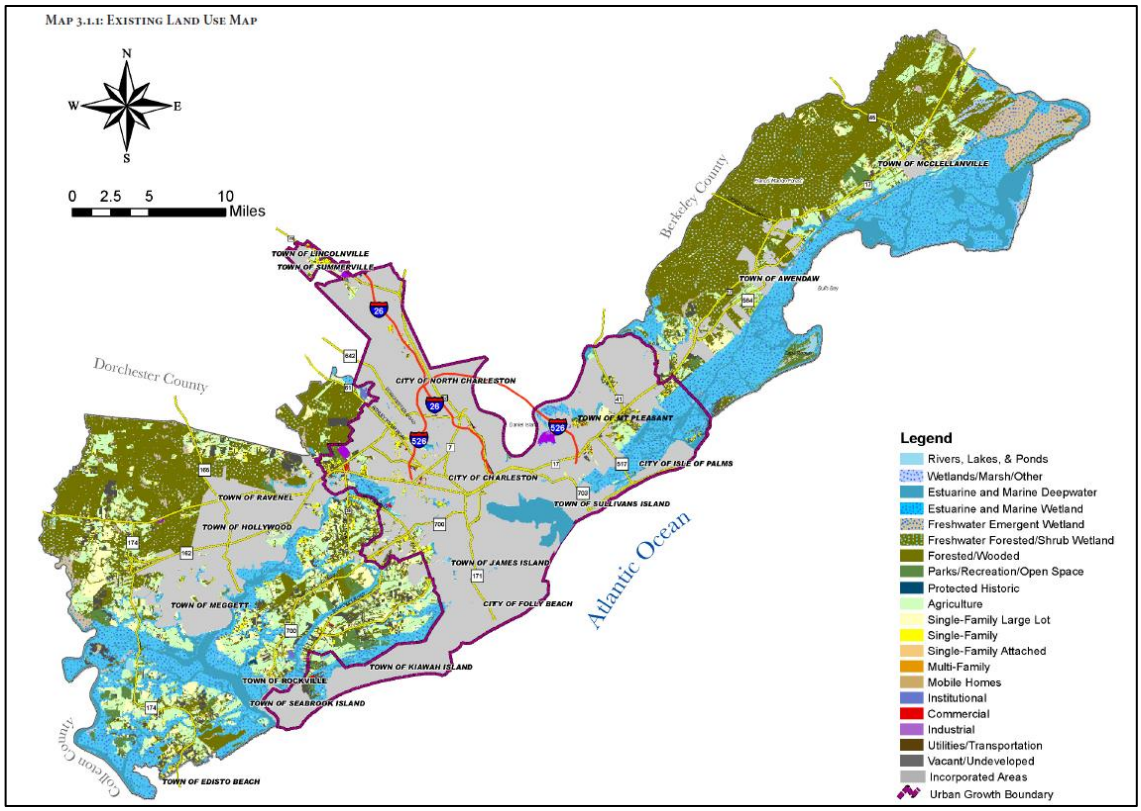


Figure 9-4. Land use map

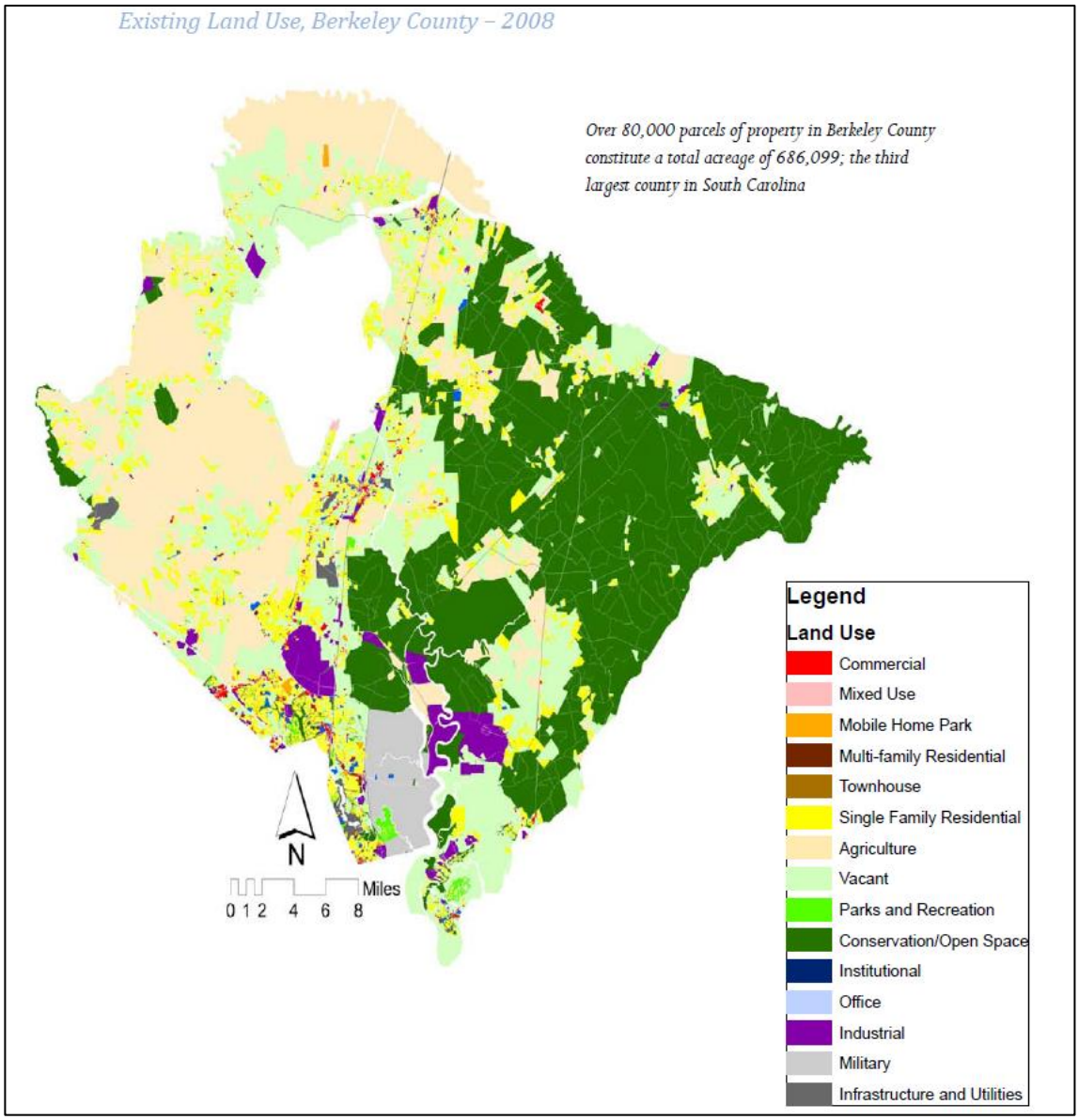


Figure 9-5. Land use map, Berkeley County (2008)

While much of Charleston and Berkeley counties remain undeveloped, both counties have experienced pressure to develop as population growth trends continue. According to the 2008 Charleston County Comprehensive Plan, since the 1970s municipalities within Charleston County have experienced not only natural population growth, but also substantial growth from the expansion of municipal boundaries by annexation. For example, in 1972 North Charleston had an area of 7 square miles. In 2007 North Charleston encompassed more than 73 square miles. Similarly, the physical size of the City of Charleston increased from 16.7 square miles in 1975 to almost 104 square miles in 2007. The Town of Mount Pleasant's planning area, which includes both incorporated and unincorporated areas, increased from approximately 19.7 square miles in 1985 to approximately 51.7 square miles in 2007. Likewise, over the past several years, Berkeley County Council has adopted, by ordinance, development plans (planned development or PD) for future residential, commercial, and industrial projects that involve well in excess of 7,000 acres and nearly 21,000 residential dwelling units. Mixed-use (residential and commercial) planned developments already approved and/or under construction are shown in Figure 9-6.

Planned Development	Total Acres	Total DU	DU/Acre	Open Space	% of Open Space	Completion (Estimated)
A. The Parks of Berkeley	4,559	13,271	2.91	1,136	25%	2040
B. Wildcat Tract	2,010	5,778	2.87	351	17%	2030
C. Spring Grove Plantation	477	1,240	2.16	34	7%	2020
D. Lazy Hill	169	420	2.48	77	46%	2020
E. Boals Farm	32	130	4.06	-	-	2020
F. The Rivers Bend	22	120	5.45	16	73%	2020
Total	**7,269**	**20,959**	**2.85**	**1,614**	**22%**	

Figure 9-6. Berkeley County development plans for future residential, commercial, and industrial projects

To preserve the rural character of the area and control intensity of development, Berkeley and Charleston counties have both identified primary "growth areas" in their most recent comprehensive plans.

The growth management tool implemented by Charleston County is the urban growth boundary, which clearly defines two distinct growth management areas—the rural area and the urban/suburban area. The urban growth boundary implements the desired county policy to promote higher intensity growth in the urban/suburban area where adequate infrastructure and services are in place, at the same time allowing for preservation of the rural character of the majority of the County. The urban growth boundary shows the possibility for higher level of residential development within 5 miles of the Francis Marion, where it extends north of the Town of Mount Pleasant.

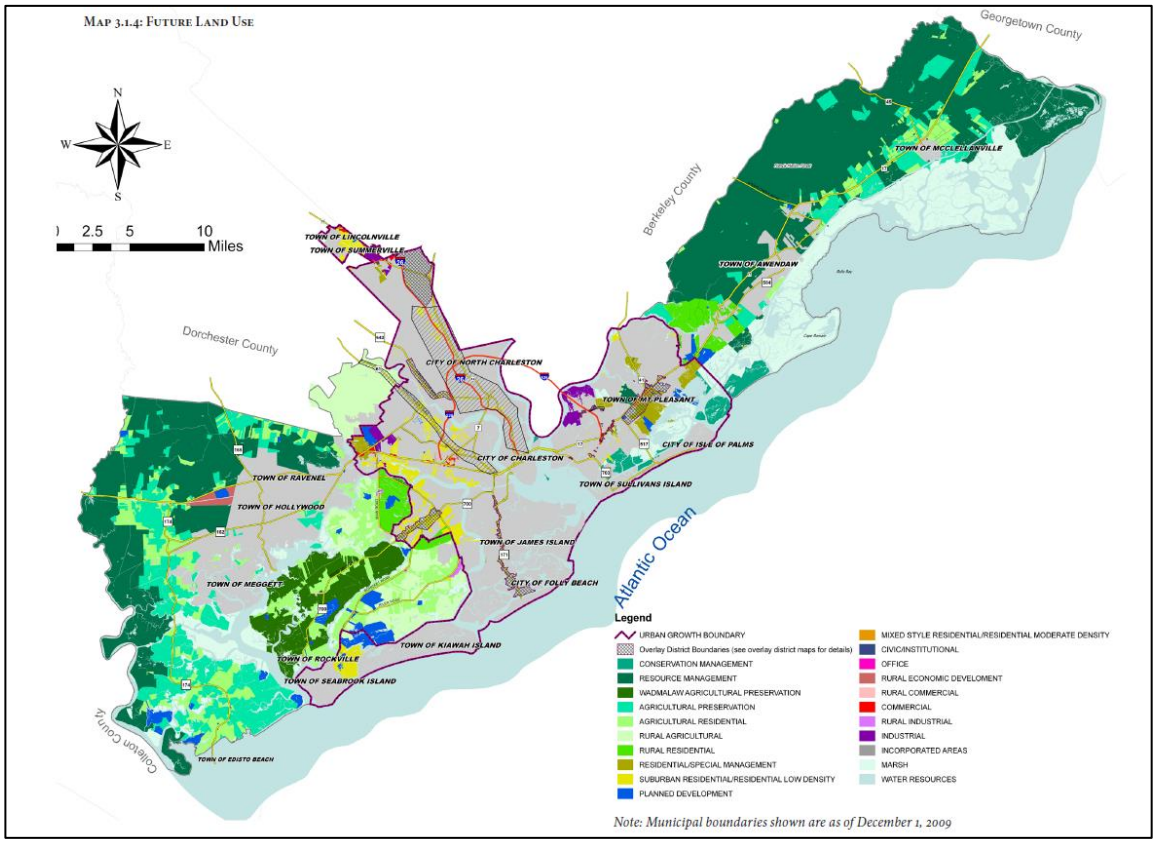


Figure 9-7. Urban growth boundary and growth management areas

The growth management tool implemented by Berkeley County is the designation of a defined principal growth area (PGA). The PGA is the area within which more intense development of various uses should occur, to be served by existing, and efficiently expanded infrastructure and other public facilities and services. It includes areas where "moderate density suburban" land use can occur, which can include single-family residential detached housing, multi-family housing, neighborhood-oriented commercial and/or mixed-uses, civic and recreation facilities. The PGA shows the possibility for higher level of residential development within 5 miles of the Francis Marion, along the entire western edge of the Forest. The largest area for development is the county seat, Moncks Corner, which is approximately 5 miles from the northwestern part of the Francis Marion.

As populations grow and become more densely located, additional areas will probably become urbanized and additional suburban sprawl will occur. Over time, sprawl will move larger populations closer to the Francis Marion, especially along its southern and western edges, thereby intensifying recreation use on the Forest.

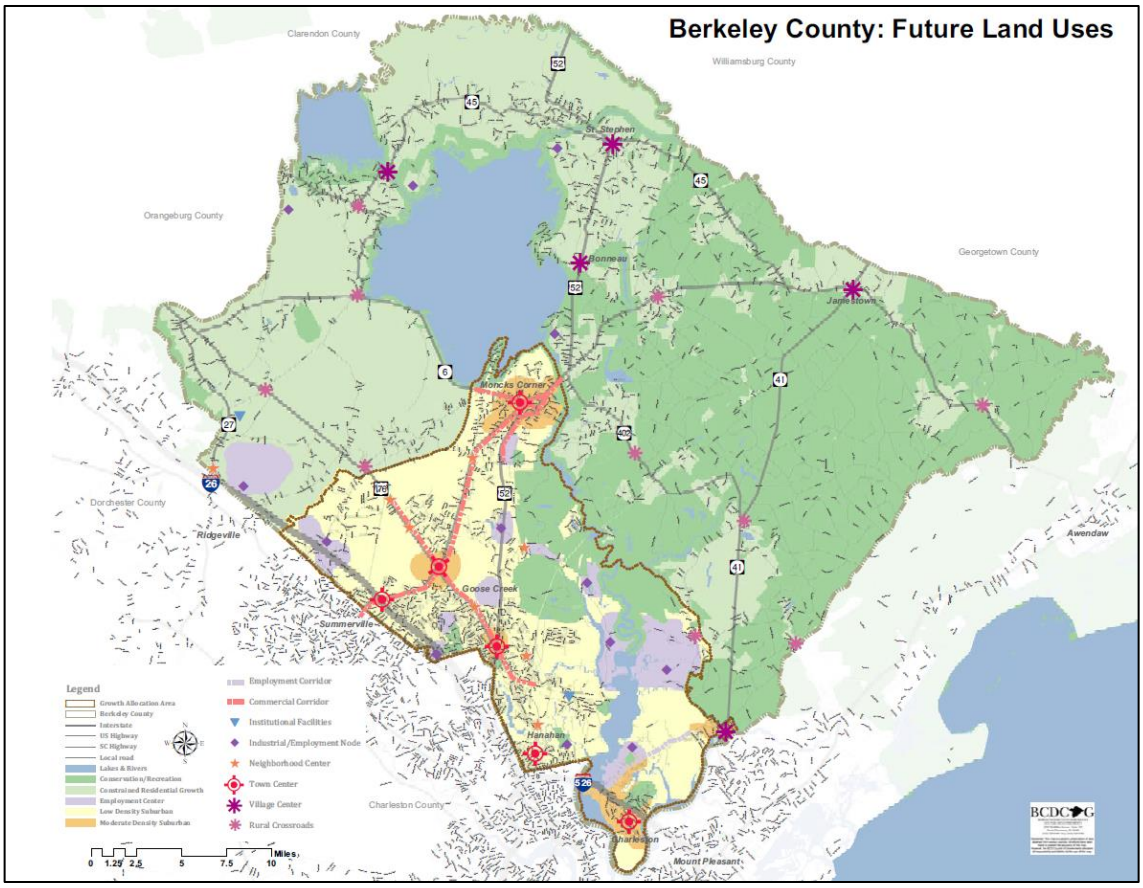


Figure 9-8. Berkely County future land uses

Recreation Resources in the Planning Area

As one of the largest land bases for outdoor recreation in the State of South Carolina, the Francis Marion is uniquely suited to provide certain types of recreation opportunities that cannot be found elsewhere.

There are numerous publicly-owned recreation parks and facilities throughout the State of South Carolina, including national and state parks, state forests, wildlife refuges, heritage preserves, and local parks. However, due to its size, none can offer the diversity, scope, and scale of the Francis Marion National Forest.

Regionally, the Francis Marion National Forest lies in Berkeley and Charleston counties. The Forest lies between historic Charleston to the south and the beach of the Grand Strand to the north. South Carolinians and tourists to the State enjoy 190 miles of coastline. The coastal beaches are the State's greatest single attraction among the various natural, historic, and man-made recreational resources and are the focal point of the State's travel and tourism industry. The 60-mile Grand Strand that extends from northern Horry County south to Georgetown County contains some of the Atlantic Coast's longest unbroken stretches of beaches. Myrtle Beach is ranked nationally as the number two beach vacation destination in the country.

Further south along the coast, the semi-tropical barrier islands of Charleston, Colleton, Beaufort, and Jasper counties offer diverse recreational opportunities ranging from the elite, manicured resort developments of Hilton Head Island to undeveloped, wilderness areas such as Cape Romain Wildlife Refuge and Capers Island State Heritage Preserve. Other coastal resources

include 240 miles of Intracoastal Waterway, extensive saltwater marshes, and numerous bays and sounds.

Outdoor recreation in the area includes the following.

Cape Romain National Wildlife Refuge. Established in 1932 as a migratory bird refuge, the U.S. Fish and Wildlife's Cape Romain National Wildlife Refuge, is 66,287 acres and encompasses a 20-mile segment of the Atlantic coast and includes a fascinating expanse of barrier islands, salt marshes, intricate coastal waterways, long sandy beaches, fresh and brackish water impoundments, and maritime forest. The refuge's original objectives were to preserve in public ownership habitat for waterfowl, shorebirds, and resident species. Bulls Island, at 5,000 acres, is the largest of the barrier islands within the refuge. It lies nearly 3 miles off the mainland and the broad, open beach is shell strewn and seems to stretch endlessly north and south.

Boneyard Beach, Bulls Island (David Okey photo)

Lake Moultrie. Lake Moultrie, owned by the South Carolina Public Service Authority, is a 60,000-acre reservoir and forms portions of the north boundary of the Francis Marion National Forest. This lake is the third largest in the State and is a significant fishery.

South Carolina Forestry Commission. The South Carolina Forestry Commission manages five State forests encompassing more than 90,000 acres in South Carolina: Sand Hills, Harbison, Poe Creek, Manchester, and Wee Tee. A wide range of outdoor recreational activities is offered and varies within each Forest. The largest State forest, Sand Hills State Forest, contains 46,000 acres and is located in Chesterfield and Darlington counties. Recreational opportunities include bird watching, nature study, hiking, hunting, fishing, and picnicking. Horseback riding, mountain bike riding, individual camping, and special events are also operated at Sand Hills on a fee basis. The closest State forest is the 12,439-acre Wee Tee State Forest, located in Williamsburg and Georgetown counties. The Forest contains more than 12 miles of frontage on the Santee River, as well as a 200-acre lake and numerous ponds and oxbows. The Forest is open from official sunrise to sunset on Wednesdays and Saturdays.

South Carolina Department of Natural Resources. The South Carolina Department of Natural Resources (SCDNR) currently manages 70 State heritage preserves totaling 81,409 acres throughout the State. These preserves range in size from 1 acre to more than 18,000 acres and are unique natural or cultural sites set aside for protection of the resource. Recreational opportunities at most sites include trails and wildlife observation, with organized nature and historical outings, picnicking, and hunting opportunities

Capers Island Heritage Preserve

provided at many of the preserves. State heritage preserves within Berkeley and Charleston counties include:

- Caper's Island (1,203 acres, Charleston County)
- Childsbury (90 acres, Berkeley County)
- Dungannon Plantation (643 acres, Charleston County)
- Fort Lamar (14 acres, Charleston County)
- Bird Key-Stono (20 acres, Charleston County, open seasonally)
- Crab Bank (22 acres, Charleston County, open seasonally)
- Deveaux Bank (15 acres, Charleston County, open seasonally)
- Buzzard Island (1 acre, Charleston County, by tour only)

The South Carolina Department of Natural Resources (SCDNR) also manages over 1.1 million acres, including 820,082 acres of public and private land and 212,682 acres of SCDNR-owned lands, in the wildlife management area program. The wildlife management area program began in 1948 with an agreement between the Forest Service and SCDNR to manage 60,000 acres of the Francis Marion National Forest. Lands in the wildlife management area program are open for public recreational activities such as hunting, fishing, wildlife viewing and nature study. More than half of these lands (about 55 percent), are owned by the Forest Service; these include:

- Santee Coastal Reserve Wildlife Management Area (24,000 acres)
- Bonneau Ferry Wildlife Management Area (10,700 acres)
- Santee Delta Wildlife Management Area

South Carolina State Park Service. The South Carolina State Park Service encompasses 47 state parks totaling more than 80,000 acres. The Hampton Plantation State Park just across the Santee River from the Forest is the only South Carolina State Park in the planning area. It is home to the remote, final remnants of a colonial-era rice plantation and serves as an interpretive site for the system of slavery that helped build such plantations in South Carolina into the greatest generators of wealth in early American history. This park is a national historic landmark, the Georgian-style mansion and well-kept grounds serve as an interpretive site for the system of slavery that helped build such plantations in South Carolina into the greatest generators of wealth in early American history.

Hampton Plantation

National Park Service. The National Park Service manages several nationally-significant park, monument, military, battlefield and historic sites in the State. Congaree National Park is the largest of these sites at more than 22,000 acres. Other national park sites preserve and/or interpret sites from the Revolutionary and Civil wars. Fort Sumter and Fort Moultrie national monuments in Charleston County are two of the most visited National Park Service properties in

the State. National Park sites offer opportunities to explore the history of the Nation through historic buildings, documentaries, displays, trails, and tours.

U.S. Fish and Wildlife Service. There are eight national wildlife refuges in South Carolina managed by the U.S. Fish and Wildlife Service. Recreational activities vary by refuge but typically include fishing, canoeing/kayaking, hiking, wildlife observation, environmental education and nature study.

The *Waccamaw National Wildlife Refuge* is the State's newest refuge and includes portions of the Great Pee Dee, Little Pee Dee, and Waccamaw rivers in Horry, Marion and Georgetown counties. The Waccamaw Refuge currently consists of 9,000 acres, but has been approved for more than 55,000 acres.

The *Ernest F. Hollings ACE Basin National Wildlife Refuge* consists of two separate units totaling 11,815 acres: the Combahee Unit located near Yemassee (7,200 acres) and the Edisto Unit on the old Grove Plantation near Adams Run (4,564 acres). Recreational activities include hiking on 9 miles of trails/access roads, fishing in the tidal creeks and freshwater streams, a limited hunting program for waterfowl and deer, wildlife observation, photography, and nature study.

The *Cape Romain National Wildlife Refuge* is located in Charleston County, spanning 66,267 acres (including 20 miles of the Atlantic coast) and providing fishing, hunting, and wildlife observation opportunities in a wide range of environments including barrier islands, salt marshes, coastal waterways, fresh and brackish water impoundments, and maritime forest. It borders the Francis Marion National Forest to the east.

The 15,095-acre *Santee National Wildlife Refuge* in Clarendon County stretches for 18 miles along the northern shore of Lake Marion and hosts a visitors center, 4 miles of trails, fishing, and a wildlife observation tower.

The *Carolina Sand Hills National Wildlife Refuge* in Chesterfield County consists of 45,348 acres equipped with wildlife observation towers, photography blinds, interpretive displays, more than 4 miles of hiking trails, and picnicking facilities.

U.S. Army Corps of Engineers. The U.S. Army Corps of Engineers, Savannah District, manages 325,000 acres of land and water along the Savannah River. The three lake projects, Hartwell Dam and Lake (55,950 acres of water and 23,566 acres of land), Richard B. Russell Dam and Lake (26,653 acres of water and 27,019 acres of land), and J. Strom Thurmond Dam and Lake (70,000 acres of water and 80,701 acres of land), are among the largest Corps projects in the country. On Hartwell and J. Strom Thurmond lakes, the Corps operates and maintains more than 90 recreation areas and leases and many additional recreation areas to State and local agencies as well as private entities for operation and maintenance. The Corps operates only two small recreation facilities on Richard B. Russell Lake. Visitors to all three lakes enjoy a wide range of recreational activities including water sports, hunting, hiking, picnicking, camping, boat ramps and fishing.

Charleston County Park and Recreation Commission. The Charleston County Park and Recreation Commission offers a diverse system of park facilities, programs, and services. It manages many county parks, including several boat landings. According to the Charleston County Comprehensive Plan, a goal of the commission is to provide at least one county park within reasonable access of each population center in the county. Currently, only 2 percent of

land in Charleston County is used for public parks, recreation, and open space (Berkeley County Comprehensive Plan 2010). The county park system continues to expand, including purchasing two properties for future parks in the northern portion of the county adjacent and near or adjacent to the Francis Marion. County Parks is currently working on a long-range county master plan and it should be available during the planning timeframe for inclusion and consideration in this process.

Berkeley County. Berkeley County has many recreational resources, most of which are commonly found in association with the area's natural and cultural resources. Examples of these include: recreational boating at Lions Beach on the shore of Lake Moultrie; recreational boating on Lake Marion; Richardson Landing boat-launching facility at Bonneau Beach; boating and fishing on the upper Cooper River and Santee River; and the Berkeley County Blueways paddling trail system. According to the 2010 Berkeley Comprehensive Plan, less than 0.5 percent of Berkeley County's total acreage (686,099) is currently being used as parks or recreation spaces. The Berkeley County Blueways paddling trail system identifies over 175 miles of total water course from 23 trails and is a result of the vision and efforts of many individuals and organizations working in partnership. Many of the trails are on the Francis Marion.

Local Cities. Local cities of Mount Pleasant, Charleston, Monks Corner and smaller towns such as Awendaw and villages like McClellanville, also provide outdoor recreation opportunities with parks and trails. Local governments maintain significant park areas and facilities. According to SCPRT's 1998 Study of Local Government Parks and Recreation Departments in South Carolina, facilities include athletic fields; community centers; swimming pools; playgrounds; tennis courts; basketball courts; picnic shelters; tracks for walking, jogging, and running; trails for walking, biking, hiking, horseback riding, and ATVs; and water trails for canoeing and kayaking. Schools are often utilized by the majority of the local recreation departments to supplement community facilities. Of note, funding for local government facilities, programs, and operations has been increasingly constrained by limits on taxing authority, fragmented jurisdictions, cumbersome annexation procedures, decreasing grant programs, and significant population growth.

Private Recreation Facilities. Private recreation facilities for public use are available in many forms: as baseball/softball fields provided by companies or civic groups; swimming, fishing and picnic areas provided by power companies; and campgrounds, marinas, golf courses, historic sites, and State-leased hunting lands. Many of these facilities charge user fees. There are also other private recreation resources which are not available to the general public, but are open only to members and guests. These include facilities such as golf courses, hunt clubs, marinas, tennis clubs, campgrounds, and various indoor facilities.

Francis Marion National Forest. The Francis Marion National Forest consists of approximately 250,000 acres in Charleston and Berkeley counties, located between the Charleston metropolitan area and the Grand Strand tourism area to the north. The Forest offers a variety of developed and dispersed recreational opportunities. The Buck Hall Recreation Area was rebuilt following Hurricane Hugo and offers electrical hookups, day use, boat launch facilities, and trailhead access to the Palmetto Trail. Visitation is limited by the weather and mosquitoes, making fall, winter, and spring the more popular seasons. The Sewee Visitor and Environment and Education Center is located on U.S. Highway 17 and operated in cooperation with the Cape Romain National Wildlife Refuge. Francis Marion National Forest has approximately 165 miles of trails. Of these, 40 miles are designated for motorcycle and ATV use.

The remaining trail miles are for non-motorized uses such as hiking, backpacking, horseback riding, mountain biking, and canoeing/kayaking. Mountain bikes are allowed on hiking trails, off-road vehicle trails, horse trails, and roads. There are no trails designated for four-wheel drive vehicles. The Forest includes two shooting ranges, several fishing areas, and a number of boat ramps. Most of the Francis Marion National Forest is included in the wildlife management area program for hunting. Four areas have been identified as federally designated wilderness, Wambaw Swamp, Little Wambaw Swamp, Hell Hole Bay, and Wambaw Creek. The Francis Marion is uniquely suited to provide areas for solitude, risk-taking, and self-reliance in natural and more primitive settings.

Collaborative Efforts and Contributions of Recreation

Recreation on the Forest contributes to the physical, mental, and spiritual health of people. According to The Outdoor Recreation Economy report, produced by the Outdoor Industry Association, the outdoor recreation economy generates $80 billion in national, State and local tax revenues each year. Cities and towns are tapping into the business of outdoor recreation because they recognize that outdoor recreation and open spaces are key ingredients to healthy communities, contribute to a high quality of life, and attract businesses and families (The Outdoor Recreation Economy, Outdoor Industry Association website). Polling data from 2008 published in the 2010 Special Report on Camping identified the leading five motivations for participating in outdoor activities as reported by campers (Special Report on Camping, 2010; Outdoor Foundation and Coleman [http://www.outdoorfoundation.org]).

1. It's fun.
2. It's relaxing.
3. I get away from my usual routine.
4. I enjoy discovery and exploration.
5. It's a great way to get exercise.

According to national research of American adults (age 16 and older) featured in (Cordell 2012), motivations may vary based upon the recreational activity, however, "getting away from the demands of everyday life" is a chief motivation for many outdoor activities, including hiking, camping, sightseeing and walking.

In summary, research shows that outdoor recreation contributes to the overall well-being of people, their physical, mental and spiritual health.

Public Policy. There is a shift in public policy surrounding community health and outdoor recreations role. The South Carolina Outdoor Recreation Plan, (SCORP, initial draft priorities, 2013) state one of the priorities as promoting healthy lifestyles and communities: Outdoor recreation, parks, and their associated amenities help keep South Carolinians and their communities fit and healthy. While the connection between health and outdoor recreation seems apparent, public health professionals and outdoor recreation providers have not always coordinated their efforts. South Carolina remains one of the top ten most obese states in the country. In 1996 South Carolina had a combined obesity and overweight rate of 51.4 percent. In 2001 it was 57.4 percent; now, the combined rate is 66.4 percent.

Berkeley County's rich history, southern hospitality, year-round cultural and outdoor recreational opportunities, and overall quality of life make it an especially desirable place to live, learn, work and play.(Berkeley Comp Plan).

Public engagement during the period of February 11, 2013, through April 11, 2013, identified several benefits, preferences, values and suggestions as related to the Francis Marion National Forest. Participants identified that they benefited from the Francis Marion National Forest in many ways, including the following:

- It provides outdoor recreation
- It provides a large area of conservation land for wildlife
- It reflects the culture and heritage of local populations
- It protects the natural environment
- It supports physical and mental well-being
- It provides a place for quiet and solitude
- It provides cleaner air and water
- It provides environmental education opportunities
- It provides food or other necessities
- It provides a place for spiritual renewal
- It provides free access to public lands
- It provides income or supports local economies
- It provides beautiful scenery

Of the benefits identified by all participants, four primary themes emerged:

1. The Forest benefits the public by providing diverse outdoor recreation experiences set within beautiful, natural scenery. In particular, the Forest is uniquely suited to provide trail, wildlife viewing, and hunting opportunities.

2. The Forest benefits the public by providing green space which can enhance quality of life through spiritual renewal, physical exercise, mental "escapes," and the opportunity for quiet reflection.

3. The Forest benefits the public by providing a large area of land for birds and wildlife to thrive. The varied ecosystems of the Forest support a diversity of birds and wildlife, including both rare, native species and migratory species such as neo-tropical birds.

4. The Forest benefits the public by reflecting the "lowcountry" heritage of South Carolina, as well as, by protecting historical sites of significance and allowing for the continuation of traditional uses.

Clearly, the Francis Marion National Forest is important for many reasons but sense of place, renewal, and recreation are important to many users. The distinctive role and contribution of the Forest to the recreation resource include:

- Public access to the rivers (Santee and Cooper) and Intracoastal waterways
- Opportunity for remoteness and solitude, away from the city and suburban sprawl
- Viewing diverse vegetation, wildlife, and culture sites
- Hunting on public lands

- Hiking, bicycling, motorized and paddling trails
- Cultivating Forest stewardship through environmental education

9.1 Recreation Settings

9.1.1.1 Current Conditions

Research has shown that visitors choose a specific setting for each recreation activity to realize a desired set of experiences. The recreation opportunity spectrum (ROS) is a planning tool which serves as a framework for planning and managing recreation settings and opportunities. ROS is the relationships between settings and experiences and is the mechanism by which the Forest Service manages recreation on national forests. The ROS inventory identifies the kinds or classes of recreation opportunities of an area as a function of its physical, social, and managerial setting characteristics. The inventory helps identify what is actually happening on the land. By zoning the Forest into different recreation settings, the Agency can maintain a sustainable set of recreation settings and appropriate opportunities within those settings. Current and future visitors can select where they recreate based on what they want to do, what equipment they want to bring, and the type of experience they want to have.

There are six major classes in the ROS used by the Forest Service: urban, rural, roaded natural, semi-primitive non-motorized, semi-primitive motorized, and primitive. The spectrum can be further divided into subclasses if the need arises.

The following is a general description of settings offered on national forest land:

Primitive is the most remote, undeveloped recreation setting on the Forest. They are areas away from roads, people, and development. These settings are essentially unmodified natural environment of a size or location that provides the opportunity for isolation from sights and sounds of people. Generally, the areas are located at least 3 miles from any open road and are 5,000 acres in size or larger. Motorized use within the area is normally not permitted. The Francis Marion National Forest has four wilderness areas that are classified as primitive. Wambaw Creek Wilderness allows motorboat use based on an existing use pattern before the wilderness was designated.

Wambaw Creek Wilderness, a primitive ROS classification

Semi-primitive non-motorized areas are less remote and can be as small as 2,500 acres and only a half-mile or more from

any open road within the area. These settings accommodate dispersed non-motorized recreation.

Semi-primitive motorized areas are less remote and can be as small as 2,500 acres and only a half-mile or greater from any open road. These settings accommodate dispersed motorized recreation.

Roaded natural settings are located within a half-mile of a road and usually provide higher levels of development such as campgrounds, picnic areas, and river access points.

Rural settings represent the most developed sites and modified natural settings on the Forest.

Table 9-1. ROS classes on the Francis Marion National Forest

ROS Class	Acres	Percent of Forest
Primitive	13,549	5%
Semi-Primitive Non-Motorized	0	0%
Semi-Primitive Motorized	21,147	8%
Roaded Natural	126,219	50%
Rural	85,181	34%
Santee Experimental Forest (reserved)	6,076	3%

The ROS for the Francis Marion National Forest was inventoried in 1996. Monitoring of projects since the adoption of the revised Forest plan revealed that the Forest acres generally met the ROS classes. However, there are some data gaps, including land acquisition since the 1996 plan needs to be inventoried. Also, an inventory update is needed to identify the appropriate ROS class for the Wambaw Creek Wilderness which allows for motorized boating since this is inconsistent with the current primitive setting objectives.

Also, only 13 percent of the Forest is managed as primitive or semi-primitive, despite its unique position to provide for these settings.

Preferences

The National Visitor Use Monitoring (NVUM) program provides reliable information about amount of recreation visitors to national forest system managed lands at the national, regional, and forest levels. However, NVUM does not capture the activities people would like to have offered (their preferences).

The South Carolina Parks Recreation and Tourism as part of its continuing efforts to meet the recreational needs of the South Carolina public, the South Carolina Department of Parks, Recreation, and Tourism periodically conducts surveys of the general public in order to determine the extent to which the State's residents participate in a variety of recreational activities as well as their preferences for such activities. Data for the most recent survey were collected between September 13 and November 18, 2005. The report provides a summary of the major findings from this survey. There are variations of preferences between age, race, gender and income made significant differences. Also, season does have a significant effect on people's preferences. This report focuses on activities in a variety of settings, not just settings. Results of the latest survey on preferences in South Carolina can be found online at http://www.statelibrary.sc.gov/scedocs.

9.2 Recreation Opportunities: Developed[10]

The Francis Marion is a unique recreation destination with many distinct settings offering a diversity of quality recreation opportunities.

9.2.1.1 Current Conditions

Recreation and Interpretive Sites

Table 9-2 lists recreation sites on the Forest.

Table 9-2. Recreation sites on the Forest

Recreation Areas	Facilities
Buckhall Recreation Area	Camping with electric hookups, picnic, boat ramp, fishing pier, trailhead
Elmwood Campground	Camping, vault toilet, game check station
Honey Hill Campground	Camping, vault toilet
Halfway Creek Campground	Camping
Awendaw Canoe Launch	Kayak and canoe launch, information kiosk, trailhead for Palmetto Trail
Twin Ponds Rifle Range	Covered shooting benches
Boggy Head Rifle Range	Covered shooting benches
Huger Recreation Area	Picnic, vault toilet, boat ramp
Interpretative Areas	Facilities
Sewee Visitor and Environmental Education Center	Visitor Center, interpretive programming loop trail, fishing
Sewee Shell Ring	Boardwalks, interpretive information
Battery Warren	Trail, interpretive information
I'on Swamp Interpretive	Trail, interpretive information

Buckhall. Buckhall is the most developed campground on the Francis Marion National Forest, with 14 RV sites with electrical hookups and 5 tent sites, shower houses, a boat launch into the Intracoastal Waterway and Cape Romain National Wildlife Refuge, trailhead for the Awendaw Passage of the Palmetto Trail, picnic area and a fishing pier. The area is open year-round. Camping fees and day-use fees are charged and reservations are made through the national reservation system.

Buckhall Boat Ramp

[10] The term "developed" recreation opportunities typically means that the use occurs within or near a facility, for instance picnicking at a picnic shelter or target shooting at a range. Often these facilities are constructed to help users enjoy the activity and to reduce impacts to the environment. "Dispersed" recreation typically means the activity or use occurs without much need for a constructed facility to enjoy the activity, such as hunting or hiking.

Occupancy for the camping is shown in Table 9-2. The mild winters and extremely hot and humid summer encourage higher winter occupancy and slightly lower summer occupancy.

Buckhalls' unique position on the Intercostal Waterway makes it a popular recreation site for a day trip or multiday. The boat launch is especially during the popular shrimp-baiting season in late summer/early fall.

The site was rebuilt after the massive devastation of Hurricane Hugo; however, it is the most costly recreation facility to maintain and operate.

Honey Hill, Elmwood, and Halfway Creek. Honey Hill Campground and Elmwood Campground accommodate more primitive camping across the Forest, with vault toilets and primitive settings. Elmwood cooperates with the SCDNR who provide staffing for the check station.

Awendaw Canoe Launch. Honey Hill Campground and Elmwood Campground accommodate more primitive camping across the Forest, with vault toilets and primitive settings. Elmwood is a popular camp during deer and turkey hunts on the Waterhorn Hunt Unit and it also serves as a South Carolina Department of Natural Resources game check station during big-game hunting season.

Rifle Ranges. There are two rifle ranges on the Forest, Twin Ponds and Boggy Head. Both sites provide covered shooting benches with a 100-yard backstop. They are very popular developed sites with year round use. There are no fees charged at these sites.

Sewee Visitor and Environmental Education Center. Sewee Visitor and Environmental Education Center is jointly operated by the Cape Romain National Wildlife Refuge and the Francis Marion and Sumter National Forests and in partnership with the South Eastern Wildlife and Environmental Education Association. The center provides visitor information and environmental education focusing on the natural and cultural history of the nearly 300,000 acres of public lands that comprise the national forest and wildlife refuge. The center features an auditorium, classrooms with a wet lab, a visitor orientation area, and an exhibit hall and gift shop. Local school districts often use the center for off-site environmental education. The site offers freshwater ponds for fishing and education, a mile-long loop train, a butterfly garden, a picnic shelter, and a live red wolf enclosure. There is no fee charged at this site.

Sewee Visitor and Environmental Education Center

Visitation to the Sewee Visitor Center has declined since 2008. Use for the visitor center is down due to downturn in the economy, fewer travelers, and fewer school trips. Environmental education is a mainstay at the center, and school districts have had to reduce trips to save transportation costs. However, the visitor center offers numerous community opportunities that foster greater connection between people and nature. Its location on U.S. Highway 17 offers visitors a prime opportunity to find out about the National Forest and Cape Romain.

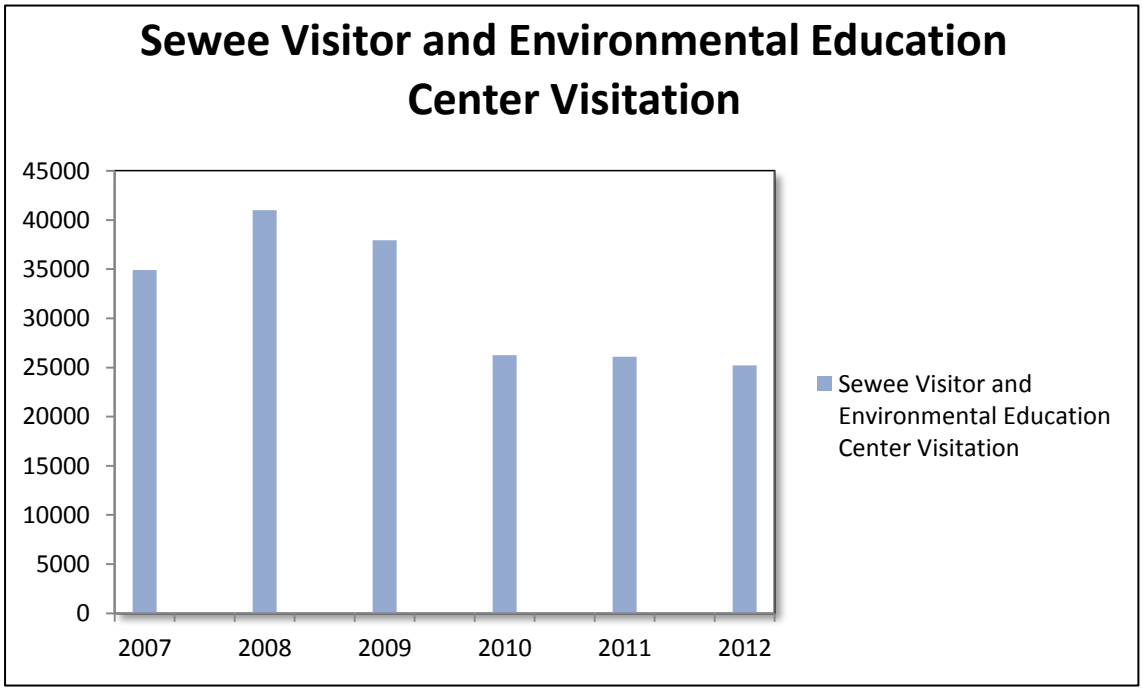


Figure 9-9. Sewee Visitor Center visitation

Source: USDI Fish and Wildlife Service (2013)

Sewee Shell Ring. This site is one of the oldest pre-historic, man-made features in South Carolina. The 4,000 year old Sewee Shell Ring was built by American Indians of the Thom's Creek culture. The ring measures about 225 feet across and 10 feet high at its highest point. Most archeologists today believe the shell ring functioned both as a seasonal home for the local prehistoric peoples and as a location for ritual feasting in religious ceremonies. A loop trail and boardwalk allow a close up look of the site.

Sewee Shell Ring Boardwalk

Battery Warren. This civil war earthen fort meant to block Union forces from moving up the Santee River is one of the best preserved coastal fortifications still in existence. An interpretive trail takes visitors through a mature hardwood forest that leads to a high bluff and viewing platform. Embankments of the old fort are still visible today.

I'on Swamp. This trail is a fascinating walk through a wetland world. This self-guided interpretive trail traverses embankments built by humans dating back by to the 1700s. The impoundments and ditches were built for rice production during the lucrative rice era of the Lowcountry. Visitors will see an array of wildlife and the occasional alligator in the pools that border the trail.

Distribution of Sites and Seasonality and Climate Change

Recreation sites and interpretive sites are located in the interior of the 250,000-acre Forest and several within a few miles of the South Carolina Highway 17 corridor, one of the main routes from Florida to states northward. Some sites are located directly on the Intracoastal Waterway and access to Cape Romain Wildlife Refuge.

Weather plays a role on the recreation use on the Forest. The mild winters on the Atlantic Coast of South Carolina help make the Forest a year round destination. The heat and humidity of the summer months can limit some outdoor recreation uses. Visitation by tourists to the Charleston area is significant and spring is typically the favored season. Climate is an important consideration for tourists' choice of destination (Lise and Tol 2002). Weather and climate are important factors that causes the seasonality of tourism, as does the school holiday schedule. Climate change is likely to change tourism seasonal pattern in the long run.

Climate change may affect recreation on the Francis Marion National Forest in the following ways:

- Changes to local ecosystems (vegetation changes due to drought, disease, fire, storms (Hugo as an example), decrease in cool water fish affecting freshwater fishing, increases in mammal size may lead to better hunting, more ticks and mosquitoes (both longer season and larger populations), low river flows affecting canoe/kayak trips, sea-level rise affecting coastal resources, including the Sewee Shell Ring, increased heavy precipitation affecting erosion rates for the Battery Warren earthen fort.
- Changes to local weather pattern (more extreme weather including more intense hurricanes and storms, higher winter temperature, more extreme heat days in summer, higher humidity affecting visitor comfort).
- Changes to human use and activity patterns (such as shifting seasonality of tourism with an increase in winter visitation and a decrease in summer visitation, competing destinations as climate regimes shift, and reduced access to destinations after disturbance [fire, hurricanes]).

Services

There are multiple outfitter guide, special use, conservation education, environmental education and volunteer programs on the Forest.

Outfitter Guide and Special Events Uses. Outfitter guides on the Forest provide services to the public to transport, guide or otherwise facilitate the recreation experience, an example would be a kayak tour of Forest streams. Special uses are typically one time or limited events that are held on Forest. These can be organized runs or trails uses, any number of limited use event.

Recreation use of the Forest provided through special use permit has increased, 425 percent in 3 years. Demand for hiking/running events has increased most significantly. The Forest has is becoming a popular place to have festivals and races which offer multiple benefits from increase business and economies and strengthen communities' connections to the Forest. There are impacts to environmental conditions without setting carrying capacities or limits for these type of events.

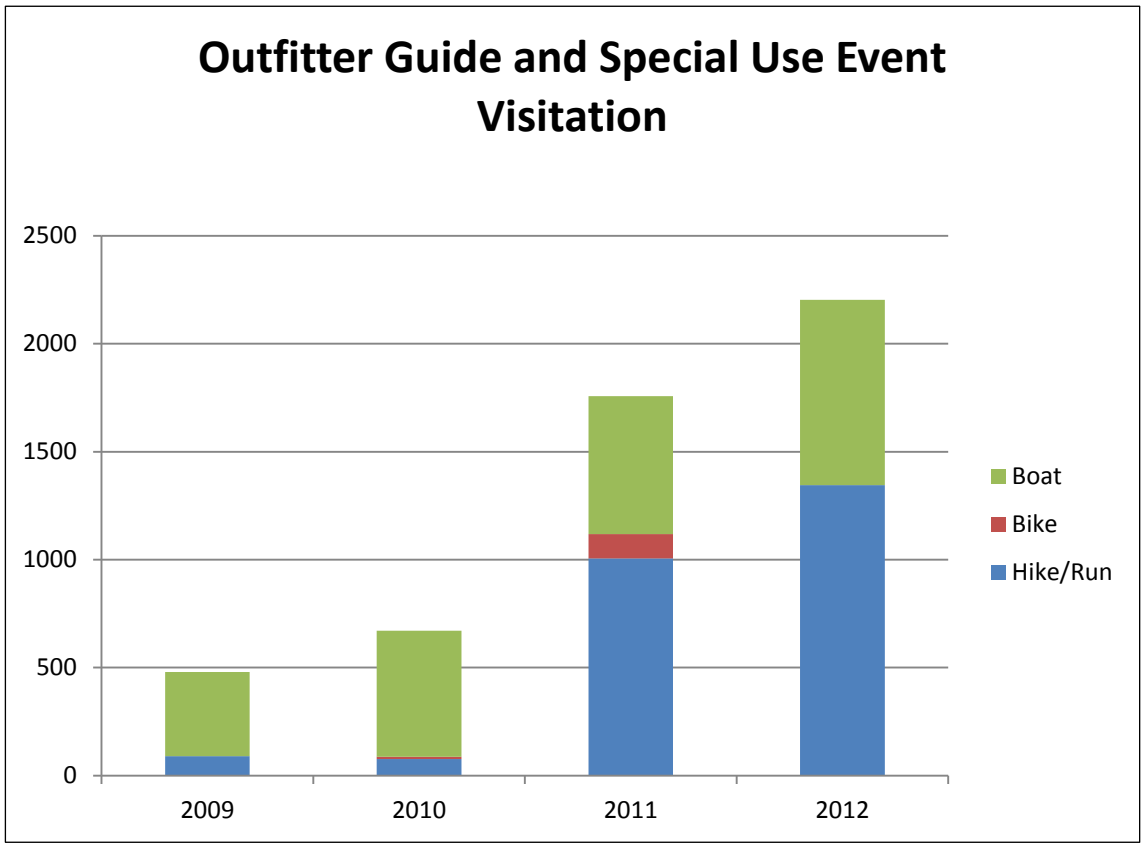


Figure 9-10. Outfitter guide and special use event visitation

Volunteers and Partners. The Forest collaborates with many recreation-focused volunteer organizations and partners. Volunteer programs are events or ongoing programs where people lend a hand and work on various projects such as picking up trash and planting native grasses. The Forest recognizes that the continued increase in demand for outdoor recreation experiences coming from South Carolina's Grand Strand to the north (including Myrtle Beach) and historic Charleston from the south, as well as both rapidly growing areas being connected to the Forest by the Highway 17 corridor, offer a great opportunity to connect the public with the Forest through volunteerism. In fiscal year 2010 volunteers contributed 10,591 hours, valued at $214,468 in today's dollars.

The Sewee Visitor and Environmental Education Center annually hosts four fishing rodeos. In partnership with the Cape Romain National Wildlife Refuge and the SEWEE Association since 2009, the Sewee Visitor Center has received more than 11,000 volunteer hours staffing the visitor information desk and delivered more than 10,500 volunteer hours of environmental education programs. The environmental education programs include the earth stewards program that involves more than 4,000 students a year on field trips, in lab experiments, and in classroom

demonstrations focusing on the natural habitats of the Francis Marion National Forest and Cape Romain National Wildlife Refuge.

Boys Scouts help plant pollinator gardens

For the past several years, the Forest has sponsored six Forestwide clean-up events that involved almost 1,000 volunteers who removed 150 tons of trash from the Forest while contributing nearly 5,000 hours of volunteer labor valued at around $100,000. Four of these cleanups were in partnership with Palmetto Pride.

A group of dedicated range users helped rebuild both shooting shelters with benches and information kiosks. Today theses heavily used rifle ranges remain clean and maintained thanks to the efforts of volunteers and their organized events.

Many of the volunteer activities on the Francis Marion involve getting children and young adults into the woods and fostering a sense of "giving back." Since 2009 the Forest has sponsored 16 volunteer projects led by the Boy Scouts of America. A cub scout troop showed up 80-strong to one such event and converted two large parking islands into pollinator gardens at the Sewee Visitor Center.

Since 2009, volunteers have worked on several low-country trails including the Swamp Fox Passage of the Palmetto Trail and the Jericho Horse Trail (includes trail bridge and boardwalk replacement). They have constructed and repaired 20 trail bridges on four different trails, totaling 1,927 linear feet. This includes replacement of 800 linear feet of wooden boardwalk at the Sewee Visitor Center with recycled plastic "wood," and building a 300-foot boardwalk at Buck Hall Recreation Area on the Intracoastal Waterway to connect the Awendaw Passage of the Palmetto Trail to the campground.

The Coastal Off-road Riders Association partnered with the Forest Service on the Wambaw Cycle Trail providing tremendous energy and labor toward maintaining the trail system. They recently constructed a beginner's loop to provide areas for beginners to learn the sport.

Conservation Education and Environmental Stewardship. The Francis Marion partners with the U.S. Fish and Wildlife Service to operate and maintain the Sewee Visitor and Environmental Education Center. The South Eastern Wildlife and Environment Education Association (Sewee Association) also staff the visitor center and provide programming. There are numerous programs and activities at the visitor center year-round. Visitors may also obtain information via kiosks at multiple developed sites and interpretive sites across the Forest. The current trend with declining Federal budget allocation for recreation on the Forest is expected to continue into the future. With this trend, partnerships and partner contributions will be even more crucial for sustaining interpretive services, conservation education, volunteer work and citizen stewardship, and special events to connect people with nature on the Francis Marion National Forest.

Use on Francis Marion National Forest

The National Visitor Use Monitoring (NVUM) program provides reliable information about recreation visitors to national forest system managed lands at the national, regional, and forest level. Information about the quantity and quality of recreation visits is required for national

forest plans, Executive Order 12862 (Setting Customer Service Standards), and implementation of the national recreation agenda. To improve public service, the Agency's strategic and annual performance plans require measuring trends in user satisfaction and use levels.

NVUM has standardized measures of visitor use to ensure that all national forest visitor measures are comparable. These definitions are basically the same as established by the Forest Service in the 1970s. Visitors must pursue a recreation activity physically located "on" Forest Service-managed land in order to be counted. Understanding the definitions of the variables used in the sample design and statistical analysis is important in interpreting the results.

National forest visit is the entry of one person upon a national forest to participate in recreation activities for an unspecified period of time. A national forest visit can be composed of multiple site visits. The visit ends when the person leaves the national forest to spend the night somewhere else.

Site visit is the entry of one person onto a national forest site or area to participate in recreation activities for an unspecified period of time. The site visit ends when the person leaves the site or area for the last time on that day.

A confidence interval is a range of values that is likely to include an unknown population value, where the range is calculated from a given set of sample data. Confidence intervals are always accompanied by a confidence level, which tells the degree of certainty that the value lies in the interval. Used together these two terms define the reliability of the estimate, by defining the range of values that are needed to reach the given confidence level. For example, the 2008 national visitation estimate is 175.6 million visits, with a 90 percent confidence interval of 3.2 percent. In other words, given the NVUM data, our best estimate is 175.6 million visits, and given the underlying data, we are 90 percent certain that the true number is between 170.0 million and 181.2 million.

The information presented here is valid and applicable at the forest, regional, and national level. It is not designed to be accurate at the district or site level. Therefore the results that follow are for both the Francis Marion and Sumter National Forest combined.

Descriptions of Forest recreational visits were developed based upon the characteristics of interviewed visitors (respondents) and expanded to the national forest visitor population.

Table 9-3. Visitation of the Francis Marion and Sumter National Forest

Visit Type	Visits (thousands)	90% confidence interval width (%)[1]
Total Estimated Site Visits	1,363.8	26.5
Developed Day Use Sites	255.6	23.3
Developed Overnight Use Site	36.6	32.5
General Forest Areas	1,057.5	33.7
Wilderness	11.4	34.3
Special Events and Organizational Camp Use[2]	2.6	0.0
Total Estimated National Forest Visits	1,283.7	27.3

[1] This value defines the upper and lower bounds of the visitation estimate at the 90% confidence level, for example if the visitation estimate is 100 +/-5%, one would say "at the 90% confidence level visitation is between 95 and 105 visits."

[2] Special events and organizational camp use are not included in the site visit estimate, only in the national forest visits estimate. Forests reported the total number of participants and observers so this number is not estimated; it is treated as 100% accurate.

Source: National Visitor Use Monitoring Report, 2008.

Demographic results show that 76 percent of visits are made by males. Black/African Americans (4.3 percent) are the most common racial or ethnic minority. There are relatively few older people in the visiting population. Only about 2 percent of visits are made by people aged 70 and up. Just over 15 percent of the visits are made by people in their twenties, and about the same percent are made by people in their forties. Over 23 percent of visits are made by children under the age of 16. This Forest serves a very local client base. Nearly 47 percent of visits come from people who live within 25 miles of the Forest; another 23 percent come from distances between 25 and 50 miles.

Over 80 percent of the visits to this Forest are people on day trips away from home. Just over 16 percent of the visits spend the night while away from their home. Of those, over 13 percent spend the night within 50 miles of the Forest. Most that spend the night in the area do so in private campgrounds not on the Forest or a private home of a friend or relative. About half of the visiting parties spend $45 or less per party per visit. Almost one-third of the visiting population comes from households in the $25,000 to $49,999 range; about 22 percent come from households in the $50,000 to $74,999 range.

An important element of outdoor recreation program delivery is evaluating customer satisfaction with the recreation setting, facilities, and services provided. Satisfaction information helps managers decide where to invest in resources and to allocate resources more efficiently toward improving customer satisfaction. Satisfaction is a core piece of data for national- and Forest-level performance measures.

The overall satisfaction results showed that almost 79 percent of the people who visited were very satisfied with the overall quality of their recreation experience. Another 16 percent were somewhat satisfied. Less than 1 percent expressed any level of dissatisfaction. The composite index results were also quite good. Developed sites and wilderness scores showed that developed facilities, access, and perception of safety all were above the 85 percent national satisfaction target. Access and perception of safety rated higher than 85 percent for undeveloped areas. The percent meets expectation scores were also quite good. Developed sites and wilderness both showed scores higher than 85 percent for developed facilities, access and perception of safety. Access rated higher than 85 percent for undeveloped areas. Importance-performance ratings were also good although there were a couple items that showed a need for attention for overnight use developed sites (availability of recreation information and adequacy of signage), general forest area (restroom cleanliness) and wilderness (adequacy of signage). The majority of the visiting population is very satisfied with road condition and adequacy of signage Forestwide. Over three-quarters of the visiting population also feel that road condition and adequacy of signage is very important.

Forest recreational visitors, while primarily local, do not reflect the racial nor gender composition of the state or counties in which it lies.

Racial and Ethnic Composition. In South Carolina, African Americans account for 28 percent of the population, 7 percent more than the national average according to the U.S. Census Bureau. The area surrounding the Francis Marion National Forest has a large African American population, with African Americans making up 25 percent and 30 percent in Berkeley and Charleston Counties, respectively (Eichman and Dobb 2013). While 25 to 30 percent of local residents are African American, the 2008 National Visitor Use Monitoring (NVUM) Report for

the Francis Marion and Sumter National Forests reported that only 4.3 percent of Forest visitors identified themselves as Black or African American, with a disproportionate number of users being White (USDA Forest Service 2008).

Data collected for the 2008 State Comprehensive Outdoor Recreation Plan (SCORP) validates that participation levels for a number of recreation activities may differ among racial and ethnic populations. As the SCORP notes, some of the largest and most consistent racial differences involve water-related activities, with a significantly higher percentage of whites than blacks participating. Differences are particularly evident for activities such as motorboating; swimming in a lake or river; going to the beach to swim or sunbathe; freshwater fishing; pool swimming; jetskiing; waterskiing; saltwater fishing; canoeing, kayaking or rafting; and shellfishing or shrimping.

The activity for which black participation was higher than that of whites and for which the difference between the races was greatest was playing basketball. A higher percentage of blacks than whites also reported playing football, volleyball, and softball; bicycling; jogging or running; and working out with weights or exercise machines. Blacks were also more likely than whites to have taken a drive for pleasure in the prior one-year period (SCORP; South Carolina Department of Parks, Recreation, and Tourism 2008). Additionally, according to the 2011 Outdoor Recreation Participation Report, most popular outdoor activities for African Americans include:

1. Running/jogging and trail running, 17 percent
2. Freshwater, saltwater and flyfishing, 11 percent
3. Road biking, mountain biking and BMX, 11 percent
4. Car, backyard, and RV camping, 5 percent
5. Hiking, 3 percent

African Americans point to lack of gear as the top reason for not participating in outdoor recreation (Outdoor Foundation 2011).

According to the 2008 National Visitor Use Monitoring (NVUM) Report for the Francis Marion and Sumter National Forests Report at least 23 percent of Forest visitors participate in (1) relaxing; (2) viewing natural features; (3) viewing wildlife, birds and fish; (4) other non-motorized activities (swim, etc.); (5) hiking; and (6) hunting. None of these reflect those activities in which African Americans are most likely to participate according to 2008 statewide SCORP findings.

Gender Composition. In 2011 women comprised 51.3 percent of the South Carolina population according to the U.S. Census Bureau [http://www.census.gov/]. In the immediate counties of Berkeley and Charleston, women represent 50.0 percent and 51.5 percent of the population, respectively. While approximately half of local residents are women, the 2008 National Visitor Use Monitoring (NVUM) Report for the Francis Marion and Sumter National Forests reported that only 24 percent of Forest visitors are women. This is below the finding made by the Outdoor Foundation in the 2011 Outdoor Recreation Participation Report which states that nationally, 44 percent of participants in outdoor activities are women (Francis Marion and Sumter National Forest 2008 [National Visitor Use Monitoring Report]).

Significant differences were evident in the participation patterns of men and women according to the results of the 2008 State Comprehensive Outdoor Recreation Plan (SCORP). The types of

activities in which men were more likely than women to participate include traditional outdoor sports such as fresh and saltwater fishing, hunting, shellfishing and shrimping, other shooting sports, and hunting dog field trials. Men were also much more likely than women to have been camping, motorboating, waterskiing, jetskiing, and lake or river swimming in a 12-month period. In addition, a higher percentage of men engaged in a number of "individual" recreational activities, such as jogging or running, off-road vehicle riding, and rock climbing or rappelling.

Women are generally more likely to engage in more passive leisure-time activities, such as visiting a zoo, museum, or historical site; picnicking; bird watching; or walking for pleasure or on a guided nature trail. More physically active recreational activities in which a higher percentage of women than men participated include horseback riding; and driving for pleasure.

Local Versus Nonlocal Visitors. There are significant differences between local and nonlocal preferences for recreation settings, opportunities, facilities and services found on the Forest.

NVUM data shows that approximately 70 percent of participants travel less than 50 miles from their residence to visit the Francis Marion National Forest, indicating most users are from surrounding local communities. Communities within Berkeley, Charleston, Clarendon, Dorchester, Georgetown, Horry, Orangeburg, and Williamsburg counties were recognized as having the strongest social ties to the Francis Marion. Additionally, the communities of Awendaw, Huger, Jamestown and McClellanville are found interspersed within the Forest and, therefore, have a very strong physical, social and economic connection to it.

According to the findings of public engagement efforts from fall 2012 through spring 2013, in which nearly all participants resided in the surrounding eight counties, four primary themes regarding Forest benefits emerged:

1. The Forest benefits the public by providing diverse outdoor recreation experiences set within beautiful, natural scenery. In particular, the Forest is uniquely suited to provide trail, wildlife viewing, and hunting opportunities.

2. The Forest benefits the public by providing green space which can enhance quality of life through spiritual renewal, physical exercise, mental "escapes," and the opportunity for quiet reflection.

3. The Forest benefits the public by providing a large area of land for birds and wildlife to thrive. The varied ecosystems of the Forest support a diversity of birds and wildlife, including both rare, native species and migratory species such as neo-tropical birds.

4. The Forest benefits the public by reflecting the "lowcountry" heritage of South Carolina, as well as, by protecting historical sites of significance and allowing for the continuation of traditional uses.

These four themes indicate local communities have high esteem for the Forests' natural and cultural offerings, value the Forests' unique ability to provide a sense of solitude, and prefer low-development, self-guided recreation opportunities.

At the Lowcountry Regional Workshop held on October 30, 2007 at Wannamaker County Park in North Charleston, Charleston County, local participants identified the "need to balance recreational activity popularity with environmental impacts and use conflicts that arise over concerns such as safety and noise," as a top issue of concern to bring forward to the State SCORP.

Conservation Areas: "Where Not to Grow": Citizens of Berkeley County have expressed their concerns over the loss of agricultural land in historic communities within rural Berkeley County, such as Lebanon and Honey Hill. While these communities have enjoyed relative isolation, unprecedented growth is beginning to threaten this isolation. Residents desire to conserve certain areas such as these throughout Berkeley County and consideration should be give as to how to preserve them through resource management corridors or the clustering of new development in such a way that these types of communities are not adversely impacted (Berkeley County 2010).

Community Visioning Preferences: Based on small group discussion notes, community facilities constitute the most current, relevant topic to the largest number of Berkeley County citizens in attendance. The average participant also could most easily incorporate a community facility into his civic vision.

Small-scale, relatively inexpensive community facilities fared the best in the public workshops. Access to the water was also a popular choice.

Its proximity to the city of Charleston also makes the Francis Marion a destination by visiting tourists and tourism to the State of South Carolina is on the rise. According to the U.S. Travel Association, a gross total of $16.5 billion was spent in South Carolina on travel or on behalf of tourism in 2011, with 53.3 percent of the total being spent by out-of-state travelers. Overall, South Carolina gross tourism spending increased 9.7 percent in 2011 and has been increasing steadily since 1990 (U.S. Travel Association 2012). About 66 percent of domestic leisure trips from out-of-state come from the following five states: North Carolina, Georgia, Virginia, Ohio and Pennsylvania according to the October 2009 report titled, "Domestic Leisure Travel to South Carolina from Out-of-State" (South Carolina Department of Parks, Recreation, and Tourism 2009). According to the same report, 18 percent of the trips have the primary purpose to participate in outdoor recreation.

From a 2001 Visitor Intercept Survey conducted by the Office of Tourism Analysis, College of Charleston, visitors to the city tend to be middle-aged (45 to 69), college-educated with an upper-middle level income. About 69 percent of survey participants sought a visitor center to inquire about opportunities within the Charleston area. A majority of participants stated that technology, both mobile technology and social media, influences their behavior and choices (Pan 2011). This is significant because according to research presented in, Taking a Benefits-Based Approach to Understanding, Planning, and Managing Nature-Based Recreation in Florida, "there are significant differences between locals and non-locals' preferences for benefits (i.e., motivations) and recreation facilities and services." The research states that, "Non-local visitors placed a high priority on exploration and education. Local visitors were looking for stress relief, sense of independence, skill building, and a feeling of achievement" (Taylor and Clark undated).

Compatibility of Uses and Unmanaged/Illegal Uses. Compatibility of recreation use on the Francis Marion is wide ranging, from fully compatible uses to uses that are not as compatible. Conflicts between users are a part of managing public land. These conflicts can increase as the number of growing recreation activities increase and new recreation technologies (such as geocaching) are developed. Public lands continue to face pressure from an increasing number of different user groups. During collaboration and public involvement, some conflicts between user groups were noted. Not all existing recreation uses and activities on the Forest are compatible.

OHV use is only allowed on designated trails on the Francis Marion National Forest. However, off-trail use happens on the Forest despite efforts to stop it. Impacts to cultural and natural resources are caused by this illegal use, especially within the areas around the current 36-mile

trail system as well as the power and transmission line rights-of way. Since 1996, according to Forest Service monitoring reports, multiple trail improvement projects were accomplished to mitigate impacts to cultural and natural resources, as well as improve the trail experience for riders. Areas such as wetlands and vernal ponds have been fenced to protect those fragile resources, but many are not protected and vulnerable to illegal off-trail use. Signage along the trail was improved. Maintenance of the trail is ongoing. As the trail conditions and maintenance improve, illegal off-trail use is decreasing (but is still a problem). There are unmanaged or illegal activities or uses, such as illegal off-trail OHV use, that impacts natural or cultural resources.

9.2.1.2 Sustainability

The 2012 planning rule directs that Forest plans must provide for sustainable recreation. The rule defines this as "The set of recreation settings and opportunities on the National Forest System that is ecologically, economically, and socially sustainable for present and future generations".

Forest Service budgets are decreasing and fewer resources are available to maintain existing recreational facilities or to develop new ones. The backlog maintenance for recreation infrastructure is estimated at $450,000 and exceeds current funding capabilities.

There has been a decrease in Agency appropriation funding for recreation over time and that trend will continue for the foreseeable future. At the same time, Forest Service facilities remain relatively unchanged in number. The backlog of and aging recreation building infrastructure continues to age and there is substantial deferred maintenance backlog. Although the Francis Marion has and pursues strategic partnerships, this leverage has never been at a scale to offset the operation and maintenance, and capital-investment needs. Contributions of partners and volunteers in promoting or maintaining recreation on the National Forest will become even more crucial in the future.

For a full discussion on the ecological sustainably of specific areas within the Forest see section 1.7 "Current Contribution to Ecological, Social, and Economic Sustainability, and Multiple Uses. For a discussion on social sustainability see section 6 "Social and Economic Assessment."

Preferences

The National Visitor Use Monitoring (NVUM) program provides reliable information about recreation visitors to national forest system managed lands at the national, regional, and forest level. Information about the quantity and quality of recreation visits is required for national forest plans. However, NVUM does not capture the activities what people would like to have offered.

The South Carolina Parks Recreation and Tourism as part of its continuing efforts to meet the recreational needs of the South Carolina public, the South Carolina Department of Parks, Recreation and Tourism periodically conducts surveys of the general public in order to determine the extent to which the State's residents participate in a variety of recreational activities as well as their preferences for such activities. Data for the most recent survey were collected between September 13 and November 18, 2005. The report provides a summary of the major findings from this survey (Table 9-4). There is large variation from season to season except for playing.

Table 9-4. Preferences of South Carolinians for certain outdoor recreation activities

	Spring or Summer		Fall or Winter	
Activity	**%**	**Rank**	**%**	**Rank**
Playing ball (softball, baseball, basketball, volleyball, football, or soccer)	21	1	20.7	2
Walking for pleasure	14.6	2	23.3	1
Swimming	11.1	3	1.2	13
Fishing	10	4	4.5	6
Golf	5.7	5	5.3	4
Camping	4.3	6	3.7	7
Motorboating	3.8	7	0.8	17
Gardening	2.9	8	1.4	12
Bicycling	2.8	9	3.5	8
Hiking	2.3	10	4.9	5
Tennis	2.3	11	1.7	11
Jogging/running	1.6	12	2.3	9
Hunting	1.3	13	6.8	3
Picnicking	1.3	14	0.5	20
Visiting a park	1.8	15	0.9	15
Motorcycling	1.2	16	0.2	22
Horseback riding	0.8	17	1.1	14
Water sports	0.8	18	0	23
Waterskiing/jetskiing	0.6	19	0	24
Kayaking	0.6	20	0.3	21
Going to the mountains	0.1	21	0.9	16
Exercising	0.1	22	0.8	18
Snow skiing	0	23	2.1	10
Ice skating	0	24	0.7	19
Others[1]	9		12.6	

[1] Total of all other activities mentioned, none of which was named by more than 0.5% of those interviewed as either their preferred spring or summer, or fall or winter, preferred outdoor recreational activity.

Source: South Carolina Recreation Participation and Preference Study, 2005.

9.2.1.3 Current Management Direction

The Revised Land and Resource Management Plan incorporates Forestwide goals and objectives, desired conditions, and standards for recreation. A Forestwide goal states:

> Provide for high quality recreational use. People use the Forest for a number of reasons. Our goals are to 1) develop, maintain and enhance a broad spectrum of recreational opportunities and interpretive services for Forest visitors to know and experience the Forest; 2) provide for safe, quality recreational experiences; and 3) provide barrier–free recreational facilities making the Forest accessible to as many people as possible.

Providing a “range”, or “diversity”, of recreational opportunities is emphasized throughout the 1996 Forest plan as a Forest goal, desired future condition, and Forest standard. Conversely, the

plan does not identify the distinctive role of the Forest to provide recreation or where management emphasis should be placed to achieve a sustainable recreation program.

Desired conditions for recreation on the Forest are:

- The Forest is a popular destination for a wide range of recreational visitors. There are more opportunities to enjoy both dispersed and developed recreational activities. Of the recreational activities offered on the Forest, about half are developed activities and half are dispersed activities.
- The quality of facilities is higher, and the user can expect to pay more fees for using the Forest. There are more miles and variety of trails including OHV, bicycle, canoe, hiking, and horse. Off–highway vehicles travel only on designated trails. Trails are in better condition and allow for shorter routes by including loops in their design. There are several new developed recreational facilities, including boat ramps, horse camps, campgrounds, and canoe access areas. Visitors enjoy a wide diversity of recreational experiences. The physically challenged enjoy more opportunities because of the barrier-free facilities. The Forest is a primary place for the public to enjoy hunting and fishing. Nonconsumptive use has also increased, and many people come here to bird watch, photograph, and simply enjoy nature. There is a greater emphasis in areas offering semi-primitive recreational opportunities.
- The interpretive program is much more developed. There are increased interest and understanding of the natural environment and the coastal region of South Carolina by both visitors and residents. The Sewee Environmental Education and Visitor Center provides quality environmental education and interpretive opportunities.

Several Forestwide objectives include:

- Increase the acres greater than 0.5 mile from an open road to 24,000 acres,
- Manage recreational experiences, facilities, and activities to meet the adopted recreation opportunity spectrum,
- Increase the developed recreational facilities capacity to 2,200 people-at-one-time (PAOTs) within the next 10 years, and to 2,600 PAOTs in the long term,
- Increase the trail system to 160 miles within the next 10 years, and
- Manage visual resources to meet the adopted visual quality objective.

Based on Forest monitoring over the last 10 years, some objectives have been met. To date, the Forest provides 174 miles of Forest Service-managed trail opportunities. About 108 percent of the objective has been met of increasing the trail system to 160 miles.

To date, the Forest provides recreational facilities with a total designed capacity of 1,414 PAOTs. About 64 percent of the short-term PAOT objective and 54 percent of the long-term objective has been met.

Generally recreational opportunity spectrum (ROS) and visual quality objectives were met, according to monitoring reports. However, there is a Forest objective to, “Manage recreation experiences, facilities and activities to meet the adopted Recreation Opportunity Spectrum (ROS).” In two instances, recreation sites are not being managed in compatibility to the ROS objectives of the larger area: (1) the Wambaw and Still boat launches are being managed as development level 3 facilities within a primitive recreational setting (Wambaw Creek

Wilderness); and (2) the Wambaw Cycle Trail is less than 0.2 mile from a primitive recreational setting and contributes noise pollution to the Wambaw Swamp Wilderness.

There are Forestwide standards that apply to developed and dispersed recreation, visual quality and ROS including:

- OHV use is restricted to designated OHV trails and, if street legal, opened roads.
- Continue to enhance the interpretive program to accurately and adequately develop an interest and understanding of the natural environment of the Forest and the coastal region of South Carolina, as outlined in the Francis Marion Interpretive Prospectus.
- Provide a coordinated program of awareness and training for all employees and partners (including outfitters and guides, governmental agencies and other interested organizations) to ensure a consistent program of public service.
- Developed recreational sites will require immediate control of wildfires at all fire intensity levels (no tolerable acreage loss).
- Vegetation along trails is treated to maintenance levels identified in FSH 2309.18. Priority is given to correcting unsafe conditions, preventing resource damage, and providing for intended recreational experience level.
- Develop a range of recreational opportunities within primitive, semi-primitive motorized, roaded natural and rural recreational opportunity spectrum classes.
- Visual quality objectives are met by corridor maintenance, site preparation, timber stand and wildlife habitat improvement, range forage and fuels treatment projects.
- Treatments are scheduled as much as possible for the season that best meets visual quality objectives. Rehabilitation and enhancement work may be needed to meet short-term visual quality objectives. Visual diversity along active travel ways (such as canopy layering, flowering trees) is protected from treatments where feasible and needed to meet visual quality objectives. Tool selection and coordination requirements are determined by a site-specific analysis at the project level.
- The landscapes around most travel routes continue to be managed to reduce the visual impacts of activities that might be seen by a passer-by. Generally, visual quality has improved. A greater portion of the Forest is classified as retention or partial retention. **There is less evidence of human activities to the casual visitor. Although human activity** may be evident in some areas, the activities remain subordinate to the characteristic landscape.

According to Forest plan monitoring the OHV use restricted to trails is difficult to achieve percent compliance for this standard. Improvements to the trail and at the trailhead have been effective in some instances. An estimate of a portion of illegal trails in 2010 documented over 2 miles of illegal trail. At the time of the 1996 plan there were estimated to be many more miles of illegal trail. Other standards, per monitoring reports, are being achieved. National visitor use monitoring has given the Agency greater confidence in the types and numbers of recreation users on the Forest, including visitors' satisfaction with the recreation and other programs.

There are two management areas that highlight recreation, management area 2–Wilderness, and management area 8–Special Areas. There are specific goals, desired future conditions, objectives and standards associated with each management area. In the remaining management

areas the emphasis on recreation is delivered mainly through the desired future condition statements.

- In MA 26 the desired future condition states, recreational experiences in this management area are roaded natural and rural, and recreational activities follow ROS criteria for those experiences. Recreational sites and trails are limited in areas that conflict with red-cockaded woodpecker nesting and cover requirements. Interpretive sites on ecosystem restoration and cultural heritage are found across this area. Recreational sites range from development scale 1–5.
- MA 27 states, this management area contains land that can accommodate a variety of recreational activities including a variety of trails and developed sites. The recreational experiences for this management area are mainly roaded natural with some rural experiences. Developed recreational sites range from development scale 1-5.
- MA 28 states, this management area contains land that can accommodate a wide variety of recreational activities including trails and recreational sites. The recreational experience for this management area is rural and roaded natural. Developed recreational sites range from development scale 1-5.
- MA 29 states, recreational facility development is generally provided to accommodate users at the perimeters of the area. Visitors are allowed to be self-reliant on their outdoor skills in an environment away from such comfort and conveniences that are normally found in developed recreational areas. Development scale ranges from 1 to 2. Honey Hill Campground is located in this management area and it is more developed (development scale 3) than the management area allows, contributing to an inconsistency in the management of the areas.

The majority of the Forest acres are in management areas 26, 27, 28, and 29. With some exceptions, (MA 2 and 8 direction, limitations in MA 26 for red-cockaded woodpecker and in MA 29), there is very little difference in plan direction for distribution of recreation programs. Direction on where to locate or emphasize certain recreation activities could be strengthened, through more place-based recreation direction.

Some recreation sites are being managed incompatible with management area prescriptions.

9.3 Recreation Opportunities: Dispersed

9.3.1.1 Current Conditions

Trails, hunting, fishing and a wide variety of non-consumptive uses make up the dispersed[11] recreation on the Francis Marion. Dispersed use is generally well distributed throughout the Forest. Hunting and fishing opportunities are abundant across the Forest, while higher developed sites and activities are slightly clustered along the Highway 17 corridor (for detailed description of hunting and fishing see section 8.3 “Fish and Wildlife.”

[11] The term “developed” recreation opportunities typically means that the use occurs within or near a facility, for instance picnicking at a picnic shelter or target shooting at a range. Often these facilities are constructed to help users enjoy the activity and to reduce impacts to the environment. “Dispersed recreation” typically means the activity or use occurs without much need for a constructed facility to enjoy the activity, such as hunting or hiking.

Trails

The trail program on the Forest includes 176 miles of a variety of trails—from hiking, mountain biking, and OHV to equestrian.

Table 9-5. Total trail mileage by type on Francis Marion

Trail Type	Miles
Hiking	68
Canoe/kayak	35
Equestrian	38
Off-highway vehicle	36
Total	**177**

The trail program offers a variety of settings for the trails, from semi-primitive motorized to more rural and roaded natural settings (see section 9.1.2 "Recreation Settings").

The 51-mile **Swamp Fox National Recreation Trail** was designated in 1979 as a national recreation trail. National recreation trails may be designated by the Secretary of Interior or the Secretary of Agriculture to recognize exemplary trails of local and regional significance in response to an application from the trail's managing agency or organization. Through designation these trails are recognized as part of America's national system of trails.

A portion of the Swamp Fox Trail was also designated as the **Swamp Fox Passage of the Palmetto Trail**. This federally designated millennium legacy trail is one of only 16 cross-state trails in the United States. The Swamp Fox Passage is currently the longest section of the cross-State trail. The Awendaw Passage of the Palmetto Trail offers another 7 miles and is the coastal terminus of the Palmetto Trail, ending at the Intracoastal Waterway.

There are several interpretive trails and shorter distance hiking trails including **Historic Battery Warren, Sewee Shell Ring, I'on Swamp Interpretive Trail, South Tibwin, Huger Loop Trail** and **Nebo Trail.**

The Forest has multiple water-based trails from blackwater to brackish to fresh water streams (Figure 9-6).

Table 9-6. Water-based trails on the Francis Marion National Forest

Water-based Trail	Length in Miles (approximate)
Wambaw Creek	8.0
Chicken Creek	9.5
Awendaw Creek	7.0
Wadboo Creek	6.0
Echaw Creek	4.5
Total	**35**

Wambaw Creek is a peaceful, wilderness blackwater creek flowing through majestic cypress-tupelo stands. There are abundant opportunities to view wildlife such as prothonotary warblers, swallow-tailed kites, and river otters. Old dikes and canals bear evidence of attempts made by early European settlers to tame this region for agriculture. Giant cypress and gum trees line the

creek, which flows down the heart of this long, slender wilderness. This trail is located within the congressionally designated Wambaw Creek Wilderness.

Chicken Creek is an 8-mile canoe trail that takes the paddler down the historic Santee River, through the fast moving confines of Chicken Creek, back onto the Santee and up Wambaw Creek to the bridge at Echaw Road.

The Awendaw Creek is brackish water trail that travels inland through saltmarsh carrying paddlers under Highway 17 and through the Forest. Depending on the water level, the creek diminishes in the cypress/tupelo swamp near Steed Creek Road. Traveling oceanward, Awendaw Creek meanders through saltmarsh and oyster banks. Views of bluffs covered with live oak and palmetto trees give way to vistas of open water and red cedar-covered dredge islands of the Intracoastal Waterway. The creek provides access to Cape Romain National Wildlife Refuge, its barrier islands and great shore birding opportunities. Paddlers can spot a rich variety of wildlife such as dolphins, blue herons, fiddler crabs, pelicans, and oystercatchers. Paddling north on the Intracoastal Waterway, the trail ends at Buckhall Recreation Area, with a take-out at the boat ramp.

Echaw Creek Canoe Trail is a small blackwater creek winds through magnificent oak-hickory stands and cypress-tupelo swamps. Opportunities for viewing bobcats, owls, wild turkeys and more occur at every bend. The abundance of well-drained forests on the bank invites exploration on foot. The 2.2 mile Hellhole Bay Canoe trail is open during higher water times of the year.

The Wambaw Cycle Trail is a 36-mile motorcycle, OHV and mountain bike trail, this sandy course winds through fragrant pine woods with shimmering hardwoods in the understory. Along the way riders can glimpse vernal ponds with bald cypress as well as turkeys and white-tailed deer. While the trail is designed for motorcycles, it can accommodate OHVs under 50 inches wide and mountain bikes. Full-sized 4-wheel drive vehicles are not permitted and there is a fee for use of the trail. The trail is the only public OHV trail in the area; the next closest is Manchester State Park, over 1 hour away. Also, this trail system is the largest public opportunity in the State. Since 1996 multiple infrastructure improvement projects (geotextiles to improve tread, fencing, signage) have improved the overall condition of the trail. However, the trail condition can be challenging to keep maintained in the sandy terrain. Resource damage has occurred on the trail and in areas adjacent to the trail along stream channels and in and around wetlands (vernal ponds).

Wambaw Cycle Trailhead

Two horse trails, Tuxbury and Jericho combine to offer 38 miles on the Forest. Jericho's 18-mile loop trail traverses a wide array of habitat types, from mature longleaf pine stands to bottomland hardwood drains, and offers captivating scenery to visitors. Horseback riders and mountain bikers may glimpse prothonotary warblers darting among the trees. Tuxbury is a 20-mile loop trail ambles along old railroad logging trams, traversing a wide array of habitat types from mature longleaf pine stands to bottomland hardwood drains. It offers captivating scenery to

visitors who may glimpse prothonotary warblers darting among swamp cypress knees or endangered red-cockaded woodpeckers in search of food in the bark of majestic longleaf pines.

Mountain bikes are allowed on South Tibwin, Wambaw Cycle Trail, Tuxbury and Jericho horses trails, Swamp Fox Trail, Awendaw Passage of the Palmetto Trail that combine over 100 miles of opportunities.

Trail systems improvements and linkages to other trails and communities are ongoing, creating additional connections to the Forest. However, the 1996 Forest plan makes no mention of broader recreational planning efforts in which the Forest contributes, such as the Berkeley County Blueways paddling trail system, the Palmetto Trail, and the Southeast Coast Saltwater Paddling Trail. The 1996 Forest plan does not provide guidance on coordination of such recreation opportunities which span beyond Forest boundaries and require multi-management. In addition to the Statewide Palmetto Trail, these other efforts include:

The **East Coast Greenway** is a developing trail system that will eventually will link Canada to Key West, Florida, and pass through Horry, Georgetown, Berkeley, Charleston, Colleton, Beaufort, and Jasper counties and accommodate bikes and walking. Over 25 percent of the route is already on traffic-free paths.

The **Southeast Coast Saltwater Paddling Trail** is a water-based trail connecting the Chesapeake Bay and the Georgia-Florida border. For over 800 miles, the trail hugs the coastal waters of Virginia, North Carolina, South Carolina, and Georgia, providing a unique opportunity for paddlers to experience an unbroken trail through four states in the tidal marshes and rivers of the southern U.S. A waypoint on the trail is Buckhall Recreation Trail on the Francis Marion National Forest.

The **Gullah Geechee Cultural Heritage Corridor** was congressionally designated on October 12, 2006. The Corridor was created to (1) recognize the important contributions made to American culture and history by African Americans known as Gullah Geechee who settled in the coastal counties of South Carolina, Georgia, North Carolina, and Florida; (2) interpret the story of the Gullah Geechee and preserve Gullah Geechee folklore, arts, crafts, and music; and (3) assist in identifying and preserving sites, historical data, artifacts, and objects associated with the Gullah Geechee for the benefit and education of the public. Multiple resources within the corridor are on the Francis Marion National Forest.

South Carolina State Trails Plan proposed multiple extension and connections in the South Carolina Regional Trails Plan for the region of Berkeley, Charleston, and Dorchester counties.

The State of South Carolina has taken a positive stance to ensure that the waterways of the State will always be available for public use. Because of its physical relation to the water, Berkeley County offers an excellent venue for kayaking as well as other water sports and the blueways in the area represent one of the County's greatest assets in terms of recreational value. The **Berkeley County Blueways** paddling trail system identifies over 175 miles of total water course from 23 trails and is a result of the vision and efforts of many individuals and organizations working in partnership (Berkeley County 2010).

Hunting and Fishing

Hunting is one of the largest recreation uses on the Francis Marion. Fishing is also very popular with over 19 managed ponds on the Forest. For a full description of hunting and fishing opportunities and management see section 8.3 "Fish and Wildlife."

Non-consumptive Uses

Many activities on the Forest are non-consumptive and include birding, nature study, viewing wildlife, bird and fish, viewing natural features (scenery), visiting historic/prehistoric sites, driving for pleasure and visiting historic/prehistoric sites. These activities can be done largely year-round with the hot summer and mild winters.

9.4 Recreation Access

9.4.1.1 Current Conditions

The Francis Marion provides access to recreation opportunities on the Forest through a multitude of options, including conventional two-wheel drive roads, motorized trails, non-motorized trails, and various types of developed sites with facilities such as campgrounds, boat launches, and picnic areas. There are over 575 miles of roads and 177 miles of trails on the Francis Marion (see section 11.4 "Roads" for a complete write-up of roads). See section 9.1.3 "Recreation Opportunities: Developed" and section 9.1.4 "Recreation Opportunities: Dispersed" for a complete write-up of trails. Due to the climate of the South Carolina coast, the use of the recreation access is generally year-round, with hot summers the most unpleasant time.

The majority of motorized access is available in the rural and roaded natural ROS settings. In the primitive setting on the Francis Marion there is currently a total of 8 miles of canoe trail that can use a 50 horsepower or less motor. The Forest is closed to motorized riding except on this designated trail system.

The Forest offers access to recreation with facilities at developed sites, including campgrounds, group camps, picnic or day use areas, boating sites, and interpretive sites. Under existing conditions on the Forest many of the recreation facilities at developed sites are in a deteriorated condition and in need of substantial capital investment for repair and maintenance. As with other forms of access, available funding has not been sufficient to address this need for capital investment because of a declining budget.

Trends for access on the Forest continue to be challenging because it is difficult to maintain infrastructure due to declining Federal budgets. Hence, the contributions of partners and volunteers in maintaining or promoting access on the National Forest will become even more crucial in the future. The Berkeley, Charleston, and Dorchester Council of Government completed a long range transportation plan for the three counties which, in addition to roads, included bicycle and pedestrian elements. The plan states transportation no longer focuses solely on roadway solutions, and in the quest for an improved quality of life, they now strive to enhance the livability of our communities. The plan acknowledges the numerous benefits of walking and biking including personal benefits (cardiovascular fitness, health and transportation cost savings), societal benefits (reduced vehicle miles of travel, improved public health through a cleaner environment,) and environmental benefits (reduces air and noise pollution and improved water quality from fewer parking lots/spaces/structures). Other than via roads, there are few physical connections linking the Forest with surrounding communities. There is great potential to "get connected" through trail networks that extend beyond Forest boundaries.

9.4.1.2 Current Management Direction

For current management direction and preliminary findings on trails see section 9.1.3 "Recreation Opportunities: Developed" and section 9.1.4 "Recreation Opportunities: Dispersed." For current management direction and findings for roads, see section 11.4 "Roads."

9.5 Scenic Character

9.5.1.1 Current Conditions

The visual management system identifies standards for managing aesthetic values and scenic quality of forests. Within the visual management system, five visual quality objectives describe a degree of acceptable alteration of natural landscape. The visual quality objectives assigned to the Forest landscape in the 1996 Forest plan are preservation (unaltered), including all wildernesses areas, retention (appears unaltered), partial retention (slightly altered), modification (moderately altered) (see Table 9-7). Visual resources on the Forest are presently managed to meet inventoried visual quality objectives. Management activities are planned and mitigation measures are prescribed so that visual quality objectives for affected lands will be met.

Table 9-7. Visual quality objectives (1996 revised Francis Marion plan)

Visual Quality Objectives	Acres
Preservation	13,812
Retention	24,785
Partial Retention	34,954
Modification	172,078
Total Inventory	**245,629**

The visual management system and visual quality objectives had been used since the mid-1970s as the preferred analysis tool for determining effects to scenery from proposed activities. However, in December of 1995, a new handbook guiding the management of scenery and aesthetics on the Forest (Agriculture Handbook 462 National Forest Landscape Management: Volume 2, chapter 1: The Visual Management System) was superseded by Agricultural Handbook 701, Landscape Aesthetics - A Handbook for Scenery Management (SMS).

During the current effort for Forest plan revision, the scenery management system will replace the visual management system. Scenery integrity objectives instead of visual quality objectives will be the frame of reference to describe the naturalness or visual resources of forestland. Scenic integrity objectives are comparable to visual quality objectives in their reference to alterations in landscape. All or parts of the resource will be re-inventoried during the plan revision process, including existing and potential scenic character descriptions of the Forest, including new acquisitions since the last plan revision.

Some common developments on forestlands that can alter scenery include large-scale powerline development and cell phone towers. Some of these developments act as visual disturbances that detract from the form, line, color, texture, pattern, and scale of the surrounding landscapes. Natural disturbances like hurricane and wildfire and insect and disease outbreaks can also detract from the scenery resource. Land management practices, like prescribed burning, can be noticeable, but for the most part the natural environment of the Forest setting remains dominant.

Critical to maintaining the quality of the recreation experience is managing the setting by preserving visual quality and valued attributes of aesthetic quality, conserving the vegetative context, and maintaining and enhancing a unique sense of place by building on what people value about that place. During public meetings, the scenery of the Forest was mentioned often with an affinity for the long leaf pine ecosystems as well as the many diverse areas of the blackwater swamps, Carolina bays, and other unique areas.

9.5.1.2 Current Management Direction

See “Current Management Direction” in “Developed Recreation” section.

9.5.1.3 Preliminary Findings

The visual management system with associated visual quality objectives will be updated with newer scenery management system, (Landscape Aesthetics: A Handbook for Scenery Management, USDA 1995).

Note: Internal information sources for this section include:

1. Geographic Information Systems (GIS) database
2. Natural Resource Management (NRM) database
3. National visitor use monitoring.
4. Recreation opportunity spectrum
5. Visual quality management
6. Local research station reports or analyses.

External information sources include:

1. State comprehensive outdoor recreation plans.
2. State or county land management planning and strategy documents.
3. National surveys on recreation.
4. Volunteered data from special use permittees.
5. Relevant analysis or information offered for consideration by the public about recreation or scenic character (i.e., Crowdbrite and public meetings)
6. Travel and tourism reports.
7. Non-governmental organization reports
8. Comprehensive plans of states, counties, or cities or plans of these governments focused on recreation, infrastructure, or transportation.

10 Renewable and Nonrenewable Energy and Mineral Resources

10.1.1.1 Preliminary Findings

1. **Renewable Energy:** While the State of South Carolina is looking into various sources of renewable energy, the Francis Marion has the potential to provide woody biomass. Today, due to growth, wood products on the Francis Marion National Forest can be sold for more valuable products, such as sawlogs or pulp. Currently, the Forest is looking at opportunities to sell logging debris to create torrified material similar to coal.
2. **Minerals:** The Forest has the potential to sell salable minerals, such as limestone, sand, or gravel, but a suitability analysis should be completed to determine where it would be appropriate to allow mining for these mineral products. There is very low potential to develop locatable or leasable minerals.

10.1.1.2 Introduction

Per direction 36 CFR 219.6(b), the responsible official shall identify and evaluate available information for the Forest for renewable and nonrenewable energy and minerals resources. Coordination with the Bureau of Land Management (BLM) on energy and minerals resources may be needed. The 1996 Forest plan does not make the "land available for leasing decision" or the "leasing decision" due to low potential for oil and gas occurrence and the lack of industry interest at that time.

10.1.1.3 Existing Information

Information regarding renewable and nonrenewable energy and mineral resources for the plan area can be found in documents from the following agencies:

Sources of information on Renewable Energy in South Carolina

- South Carolina Department of Energy [http://www.energy.sc.gov]
- South Carolina Forestry Commission
- U.S. Department of Energy [http://www.eere.energy.gov/]

Sources of information on Earthquake Hazards in South Carolina

- South Carolina Emergency Management System [www.scemd.org]
- University of South Carolina Seismic Network [http://scsn.seis.sc.edu/]
- South Carolina State Geologist's Office, South Carolina Department of Natural Resources [www.dnr.sc.gov/geology/earthquake.htm]
- U.S. Geological Survey information on South Carolina [http://earthquakes.usgs.gov/regional/states]
- Picture Collection of 1886 Charleston Earthquake [http://eas.slu.edu/Earthquake_center/1886EQ]

Sources of Information on Mining in South Carolina

- South Carolina Department of Health and Environmental Control, Mining and Reclamation [http://www.scdhec.gov/environment/lwm/html/mining.htm]
- South Carolina Department of Health and Environmental Control, Ocean & Coastal Resource Management [http://www.scdhec.gov/environment/ocrm/czmp.htm]

The following laws and regulations pertain to renewable and nonrenewable energy and mineral resources:

- Minerals (Subpart A–Locatable Minerals, Subpart B–Leasable Minerals, Subpart C–Disposal of Mineral Materials, Subpart D–Miscellaneous Minerals Provisions, Subpart E–Oil and Gas Resources) (36 CFR 228)
- Land Uses (36 CFR 251)
- Land Withdrawals (43 CFR 2300)
- General Mining Law of 1872 (as amended)
- Mineral Leasing Act of 1920 (as amended)
- Materials Act of 1947 (as amended)

The following Forest Service manuals (FSMs) and regional supplements pertain to renewable and nonrenewable energy and mineral resources:

- FSM 2760–Withdrawals
- FSM 2800–Minerals and Geology

To ensure that the best available science on renewable energy development was used, the South Carolina department of energy was contacted about on-going efforts to develop renewable energy in South Carolina. Local databases were reviewed for information on nonrenewable energy and minerals management on the Francis Marion National Forest. Information on earthquake hazard in South Carolina was obtained from South Carolina Department of Natural Resources, U.S.C. Department of Earth & Ocean Sciences, and South Carolina Geologic Survey.

10.1.1.4 Current Conditions and Trends

Forest Plan Direction on Minerals and Energy

There is no Forest plan direction specific to the development of renewable energy, but some language on forest products is relevant to developing wood biomass. Objective O-9 in the Forest plan states, “Create conditions on 38,000 to 50,000 acres of pine stands which release overcrowded live crowns, increase residual stand growth potential, allow more sunlight to the forest floor and increase suitable habitat for the red-cockaded woodpecker.”

The 1996 Forest plan does not make the “land available for leasing decision” or the “leasing decision” due to low potential for oil and gas occurrence and the lack of industry interest at that time. the desired future condition for nonrenewable energy and minerals in the 1996 Francis Marion Forest Plan includes, “The landscape of the Forest shows some signs of mineral activity. Since the potential for oil and gas resources in the Atlantic coastal plain is low, most signs of activity are from gravel and sand pits, ceramic, heavy metal and pigment operations.”

There is some direction by management area.

- **Management Area 2 Wilderness:** Standard MA2-8: No mineral extraction will be allowed.
- **Management Area 8 Special Areas:** Standard MA8-1: Special use permits are allowed for activities that are consistent with maintaining the value of each scenic area.

Renewable Energy

Renewable energy includes biomass, wind, solar, ocean power, geothermal, and hydroelectric energy. Currently, there is limited renewable energy being produced on the Francis Marion. At the administrative office, ground-source heat pumps are used to reduce energy costs. At some remote sites, solar photovoltaic batteries are used. Firewood permits are sold to the public for personal use.

A 2007 study reviewed mature, commercial, and emerging technologies (GDS Associates, Inc. and La Capra Associates 2007). Some of the renewable energy resources reviewed in these studies include: wood biomass, wind, solar, tidal, geothermal, and hydroelectric energy. GDS Associates, Inc. and La Capra Associates (2007) conclude their report with these findings: "The biggest contributor to renewable energy production would derive from biomass (landfill gas, wood, agricultural by-products). The next would be hydro. Offshore wind may become a large contributor if projects can be permitted."

As a follow-up to this 2007 study, the South Carolina Department of Energy commissioned two studies to research the potential development of off-shore wind and other renewable energy options in the State (Colbert-Busch et al. 2012; Black and Veatch 2012). While these studies reviewed the potential to develop renewable energy technologies using solar, wind, ocean power, geothermal (ground source heat pump) agricultural resources, organic waste resources, waste oil resources, landfill gas, the findings on these resources are not reported here since they do have any potential for commercial development on the Francis Marion. Wood biomass and small hydropower or micro-hydropower are the only renewable energy technologies discussed in this section of the assessment.

Wood Biomass. GDS Associates and La Capra Associates (2007) noted that the use of wood in direct-fired boilers for electricity generation is a well-established technology. For the 2007 report, the authors assumed that direct-fire biomass facilities would use a mix of wood biomass, urban wood waste and agricultural by-products to generate electricity.

The 2004 Integrated Resource Review recognized the opportunity for biomass sales which have now been implemented. Over the last 10 years the Forest used seven stewardship contracts to develop wood biomass opportunities and reduce fuel loading in the wildland-urban interface. The Forest thinned small-diameter woody materials (2 to 8.5 inches) from post-Hugo regeneration located along major highways and near Charleston, where prescribed burning is restricted due to smoke management concerns. Approximately 283,615 tons of woody material was sold to generate electricity at a local mill.

Today, due to growth, wood products on the Francis Marion National Forest can be sold for more valuable products, such as sawlogs or pulp. However the Forest is looking at opportunities to sell logging debris to create torrified material similar to coal.

Small Hydroelectric. Most of the conventional hydroelectric potential (with impoundments) in the State has already been developed. There is limited potential to develop sites for small hydro (1−30 MWa) run-of-river projects (without impoundments) on the Francis Marion (U.S. DOE

2006). The Francis Marion has not received any requests to develop a small or micro-hydroelectric facility.

Trends and Drivers

Currently, the potential to develop renewable energy for many technologies on the Francis Marion is non-existent to low, except for wood biomass and possibly small hydroelectric or micro-hydroelectric, which does not require impoundments.

The demand for renewable energy is closely linked to the price of fossil fuels, legislative requirements, and tax incentives. Wood biomass has been used for many years as a by-product of logging operations and continues to be a valuable commodity. The trend for this product is tied closely to the productivity of the logging industry; but biomass energy has not shown that it can stand alone as a strictly renewable energy resource. An emerging technology that was not assessed in the GDS Associates and La Capra (2007) report and may have some potential in the future is biomass gasification. Gasification costs need to be reduced and gasification issues resolved before being competitive with more mature technologies that can utilize wood biomass.

Selling woody biomass has the potential to provide revenue to the local economy through electricity generation and other value added products, and as a result contribute to social and economic sustainability. See section 6 "Social and Economic Assessment" for additional discussion on how the Francis Marion National Forest contributes to social and economic sustainability. Some organic matter is removed from the logging site, which could have some impacts to soil productivity and therefore some impact to ecological sustainability.

Nonrenewable Energy

Nonrenewable energy resources consist of coal, oil, and natural gas. There are no oil, coal, or natural gas developments on the Francis Marion National Forest and the potential to develop these sources on the Forest is non-existent with current technology. See section 10 "Renewable and Nonrenewable Energy and Mineral Resources" for more details.

Minerals

The Francis Marion has no mineral activity at the present time. With respect to National Forest management, mineral resources are divided into three groups: (1) locatable minerals, (2) leasable minerals, and (3) salable minerals. The authority of the Forest Service to influence and regulate the exploration, development, and production phases of mining operations varies with each group. Therefore, the Forest Service manages mineral resource programs that are specific to each group.

Locatable Minerals. Locatable minerals are those valuable deposits subject to exploration and development under the General Mining Law of 1872 (as amended). These resources are commonly referred to as hard-rock minerals and include gold, silver, and copper.

The General Mining Law of 1872 grants every U.S. citizen the right to prospect and explore lands reserved from the public domain and open to mineral entry. The right of access is guaranteed and is not a Forest Service discretionary action.

By law, certain lands—such as lands withdrawn by an act of Congress (e.g., through the Wilderness Act of 1964 or the Wild and Scenic Rivers Act of 1968) or lands withdrawn by an order of the Secretary of the Interior—are withdrawn from mining claim location. These withdrawn areas are, however, subject to mining claims with valid existing rights established

before the date the areas were withdrawn from mineral entry. As a consequence, some mining claims located within existing or proposed withdrawn areas could be developed in the future.

Upon discovering a valuable mineral deposit, citizens have the right to locate a mining claim and remove the mineral resources. The citizen holding a mining claim is the claimant and is responsible for initiating mining activities and investing the capital required to conduct mineral exploration, site development, mine operation, and reclamation of the site.

The Forest Service works with mining claimants to provide reasonable access to their claims, minimize adverse environmental impacts on surface resources, and ensure reasonable reclamation of lands affected by mining operations. To protect surface resources, the Forest Service reviews the mining plan of operations submitted by the claimant; discloses impacts of the proposed mining operations in a site-specific environmental document; approves only those activities that are reasonably necessary for the proposed operation; monitors operations to ensure environmental standards are met; and ensures prompt and reasonable reclamation of disturbed areas.

No known deposits of gold, silver, or copper occur on the Francis Marion National Forest. There are no known outstanding mineral rights. Across the Francis Marion there are no approved plans of operations for various small lode and placer mining sites; there is no approved exploration activity investigating larger deposits. Any person proposing to conduct operations that might significantly disturb surface resources must submit a notice of intent to operate. The Forest has not received any suich notices.

Leasable Minerals (Oil and Gas). Certain types of minerals, primarily energy resources, are not subject to mining claim location, but are available for exploration and development under provisions of the Mineral Leasing Act of 1920 (as amended). Access to these types of minerals is provided through leases, permits, or licenses that include fee and/or royalty payment conditions. Federally owned leasable minerals include oil, gas, coal, geothermal resources, potassium, sodium, phosphates, oil shale, sulfur, and locatable minerals on lands that have been acquired and are no longer considered public domain lands.

The BLM retains the authority to manage these minerals. The BLM is statutorily required to obtain consent from the Forest Service before issuing leases for leasable minerals on national forest system lands.

By regulation (36 CFR 228.102) certain lands are legally unavailable for leasing: lands withdrawn from mineral leasing by an act of Congress or by the Secretary of the Interior; lands recommended for wilderness allocation by the Secretary of Agriculture; and lands designated by statute as wilderness study areas (unless oil and gas leasing is specifically allowed by the statute designating the study area).

No potential for oil, coal, or natural gas development is known on the Francis Marion National Forest. This lack of potential is due in part because there is no triassic basin in South Carolina. Hydrofracking may make development possible for oil if it is determined that there are unmetamorphosed shale formations under the Francis Marion. However, these shale formations are typically found in the mountains and not in the coastal plains. The potential is expected to remain low to non-existent. There are no leases or have been any leases in the past. There may be some tracts with a minor royalty interest.

Mineral Materials. Often referred to as salable minerals, or common variety minerals, mineral materials are subject to the Materials Act of 1947 (as amended). These minerals are disposed of by sale, through issuance of free-use permits, or under contracts for in-service needs. Mineral materials may include petrified wood and common varieties of sand, rock, stone, cinders, gravel, pumice, clay, and other similar materials. Such common-variety mineral materials include deposits that tend to be relatively widely available; although they have economic value, they do not have a distinct and special value. These minerals are most commonly used as building, landscaping, and construction materials.

South Carolina Department of Health and Environmental Control's Mining and Reclamation Section conducts the administrative and technical review on all applications for mining permits. The time spent conducting the review depends on the type of permit, complexity of the proposed operation, potential for environmental impact, and proposed reclamation (SCDHEC 2013a).

Berkeley and Charleston counties are covered by the South Carolina Coastal Zone Management Program. The South Carolina Coastal Management Program was established under the guidelines of the national Coastal Zone Management Act (1972) as a state-Federal partnership to comprehensively manage coastal resources. It was authorized in 1977 under South Carolina's Coastal Tidelands and Wetlands Act with the goal of achieving balance between the appropriate use, development, and conservation of coastal resources in the best interest of all citizens of the state (SCDHEC 2013b).

DHEC's Office of Ocean and Coastal Resource Management is the designated State coastal management agency responsible for the implementation of the State's Coastal Management Program. Implementation includes the direct regulation of impacts to coastal resources within the critical areas of the State including coastal waters, tidelands, beaches and beach dune systems; and indirect certification authority over Federal actions and State permit decisions within the eight coastal counties. All mining permits in S.C. Coastal Zone Area must be certified by SCDHEC's Office of Ocean and Coastal Resource Management as being consistent with the S.C. Coastal Zone Management Act (SCHDEC 2013a).

While there are no mineral operations occurring on the Francis Marion, there is potential for two salable products: limestone and sand.

Limestone: Currently Martin Marietta is mining limestone near Jamestown. The company is producing products for road base and agricultural fertilization, which are considerable salable mineral products. In the past the Forest has received proposals for mining limestone. Each proposal was turned down for various reasons. Since the Agency could only give a 5-year minerals material contract, the inquirers have not pursued it further. While the Gulliard Lake Scenic Area has limestone, it is protected from mining as a Forest-designated scenic area.

Sand: There is the potential for dredging sand from rivers. A special use permit from the Forest Service may be needed, depending on who owns the river bed. On larger rivers, the State owns the river bed and the South Carolina Department of Health and Environmental Control would process the sand dredging permit. On smaller rivers, where the river bed is national forest land, the permit would have to be approved by the Forest Service. No requests have been received by the Francis Marion National Forest to develop sand dredging operations.

Trends and Drivers

The housing industry impacts the amount of mineral materials sold in the higher-population centers of the Francis Marion. Growth in the Charleston and Georgetown areas is expected to

continue. As new houses are built and the demand for road or building materials increases, the demand for limestone or sand materials may increase.

From past evaluations, mineral activities in the Dutart Creek vicinity on private lands may be impacting ground water or could be causing land subsidence. However, the Forest has not been monitoring these impacts. Other mining issues are presenting themselves on a piecemeal basis on the edge of the Forest that may have impacts in the future.

Making mineral material available, such as limestone or sand, has the potential to provide revenue to the local economy and contribute to social and economic sustainability. See section 6 "Social and Economic Assessment" for additional discussion on how the Francis Marion National Forest contributes to social and economic sustainability. Mining does remove resources from the site, and therefore has the potential to impact ecological sustainability. Any mineral operations on national forest land would require a site plan that would limit impacts to the environment and limit impacts to ecological sustainability to the immediate area.

Geologic Hazard

It is too deep to bedrock for radon, methane, asbestos, erionite to pose any health risks. There are no known risks from landslides, mud flows, debris flows due to the flat topography. There are no known potential for volcanoes or karst collapse in the coastal plain area of South Carolina. Flooding is discussed in section 3 "Additional System Drivers." Earthquakes risks are discussed below.

Most of South Carolina's earthquakes occur in the Coastal Plain where the underlying rock is very faulted or broken from the break-up of the plates. Approximately 70 percent of the earthquakes in South Carolina occur in the Coastal Plain, with most clustered around three areas of the State: Ravenel-Adams Run-Hollywood, Middleton Place-Summerville, and Bowman (SCDNR 2013).

Geologically, Charleston and the Francis Marion National Forest fall in one of the most seismically active areas in the eastern U.S. On August 31, 1886, a magntude 7.3 earth quake shook the Charleston area. This is the most damaging earthquake to occur in the southeast United States and one of the largest historic shocks in eastern North America (USGS 2013).

The seismicity clusters around the cities of Summerville and Bowman, known at the Middleton Place-Summerville Seismic Zone) (SCDNR 2013). This seismic activity is believed to be caused by two faults: Woodstock and Ashley River. The Woodstock Fault, which runs through it, has been active for thousands of years, and will likely be active for thousands more. The Francis Marion National Forest is located in this zone.

Since 1886, there have been a number of medium-sized (and thousands of small) earthquakes in South Carolina. The Middleton Place-Summerville Seismic Zone experiences between 10 to 15 earthquakes every year, but the majority have been less 3.0 in magnitude and therefore do not attract much attention (U.S.C. 2013; SCDNR 2013). The average time between catastrophic earthquakes is approximately 500 to 550 years. However, this does not give any prediction of when the next catastrophic earthquake will strike.

Potential secondary effects of an earthquake include landslides, soil liquefaction, and fire (SCDNR 2013).

Landslides. Landslides occur in hilly/mountainous region and are not a risk on the Francis Marion due to the flat topography.

Soil Liquefaction. Movement caused by earthquake forces water to seep into the material beneath a building. The saturated granular material can lose its strength and briefly change from a solid into a liquid. When this occurs, the foundations of building will become unstable and sink into the ground (SCDNR 2013). There are some potential liquefaction areas noted on the Francis Marion National on the geologic hazard map for South Carolina (SCDNR 1996). This risk of soil liquefaction varies with the magnitude and epicenter of the earthquake and cannot be predicted for the Francis Marion.

Fires. The movement from earthquakes can rupture gasoline and natural gas pipes or damage electrical lines, which can cause fire. In addition, the earthquakes can disrupt water service making it more difficult to fight fires. The risk of fire outbreaks varies with the magnitude and epicenter of the earthquake and cannot be predicted for the Francis Marion.

Transmission Corridors

The Forest has transmission corridors, and numerous powerlines to homes and businesses in the area. It is highly likely that transmission corridors would be developed in the future and would most likely follow U.S. Highway 17, I-526, or I-26.

Table 10-1. Miles of rights-of-ways on the Francis Marion National Forest

Type	Mileage
Electric	56.2
Gas	27.3
Other	3.9
Grand Total	**87.4**

Source: GIS data.

10.1.1.5 Information Needs

The minerals program has a need for the acreages of leasable lands, locatable lands, and lands with outstanding mineral rights. The minerals program also needs an inventory of abandoned quarries and gravel pits located on the Forest. The issue is increasing demand for sand and limestone on the Forest and what and where (if at all) this use should be allowed. A geologic suitability analysis needs to be completed to determine the suitability of the Forest to supply minerals, oil, and natural gas.

11 Infrastructure

11.1.1.1 Preliminary Findings

Roads and Bridges. There are currently 576 miles of existing Forest roads and 32 associated bridges located on the Francis Marion. As stated in the 1996 FEIS, there were 603 miles of Forest roads, which may have included arterial Federal, State, and county roads. The current facilities managed by the Forest have been categorized by management and maintenance objectives. Current condition of the roads can be categorized as fair-to-adequate to fair. Due to acquisition of new tracts with established roadways the number of designated Forest roads has increased. The greatest potential for management of these roads is to continue condition inventories and maintain to ensure public safety and meet administrative needs. Consideration should be made to collaborate with local and state governments to consider easements for future management. This would be accomplished through the special use process.

Trails and Bridges. A total of 177 miles of trails and 23 associated bridges are identified and currently managed by the Forest. About 40 percent of the trails miles meet national standards. A trail or trail segment that "meets standard," (1) meets all critical national quality standards, (2) meets at least 80 percent of the remaining national quality standards, and (3) has little to no deferred maintenance. The majority of the associated bridges meet standards.

There is evidence of some user-created trails, especially where Forest trails are near private properties. There is potential for decommission, expansion, re-designation, and re-location of these trails through collaboration with local governments (Title II funds), volunteers and existing trail organizations (Palmetto Conservation Fund, CORRA). Maintenance needs will be identified through periodic inspections and corrective actions taken as needed to ensure public safety. See section 9, "Assessing Recreation Settings, Opportunities, Access and Scenic Character."

Non-Recreation Facilities. There are inventoried 48 non-recreation facilities on the Forest. There has been a decrease in the number of buildings on the Forest due to the sale of three former GOV locations in McClellanville, the former Witherbee office and work center complex and demolition of a pole shed at the Witherbee Work Center site. The condition of office facilities has improved with the co-location of personnel into the newly constructed Francis Marion office, but the remaining buildings should be categorized as adequate to fair due to age, general wear and tear, and minimal maintenance. The greatest potential is for decommission of outdated and inferior facilities and consideration for management of existing facilities through collaborative management. Examples are Walnut Grove and North Tibwin. Periodic, required condition inventories will identify safety concerns for correction.

Recreation Facilities. There are 20 inventoried recreation facilities on the Forest. The greatest potential is to consider decommission, coincident use/designation or concession of specific facilities. Concession would be on case-by-case basis through the special use permit process (see "Recreation" section).

11.1 Introduction

Existing information regarding management of infrastructure can be described under several main areas including transportation (roads and trails), facilities (buildings and support systems),

recreation facilities, and special use authorizations. The following documents provide information and management direction regarding infrastructure:

- National Roads Policy (36 CFR 212)
- Forest Service Manual 7700 and 7710
- Inventory (Natural Resources Management System, INFRA)
- Transportation Analysis Process (TAP)
- Forest Facilities Master Plan
- Energy Policy Act 2005
- Recreation Sites Inventory (INFRA)
- National Visitor Use Monitoring (NVUM)

11.2 Transportation

National forest system roads and trails are mainly in place on the Francis Marion National Forest to provide access primarily for recreation, timber, prescribed burning, and wildlife management. The Forest transportation system is well integrated with state and county road systems and forms the transportation backbone for this area of the Lowcountry. Communities and a variety of commercial activities depend on this transportation system for access to private lands, but also as transportation routes for school busses, mail delivery, and commercial traffic. Undesignated roads were not identified or analyzed. Many of these are blocked or closed.

According to South Carolina Department of Transportation, a project is scheduled in Charleston and Berkeley counties, for replacement of the Highway 41 Wando Bridge. This project will replace an outdated draw bridge at the county line. According to Charleston County there are several projects identified affecting National Forest access. Those completed include Doar Road and Duffield Roads re-surfacing projects completed in 2008. One current project is identified as Old Georgetown Road re-surfacing (Charleston County). There are several Forest roads utilized as school bus routes in Berkeley County including Hoover Road, Conifer Road, Farewell Corner, and Tuxbury that could be considered for maintenance by Berkeley County or easements issued to the county. Emergency hurricane evacuation routes have been identified through the Forest as well.

Berkeley and Charleston counties have been experiencing rapid growth over the last 10 to 15 years with new homes, communities, and businesses springing up along public roads on private lands adjacent to the national forest. Many of the major state and county roads have been or are being improved to accommodate the increased population and traffic. This trend is expected to continue to increase into the foreseeable future. This has also led to increased use of national forest system roads and trails by the public for a variety of recreational activities including hunting, fishing, hiking, biking, kayaking/canoeing, wildlife viewing, special use events, and off-highway vehicle use on the Wambaw Cycle Trail. The Palmetto Trail system traverses the length of the State and is a popular draw for many hikers. Biking activity has also increased on state, county and national forest system roads and trails.

11.2.1 Roads

11.2.1.1 Existing Information

Travel analysis was recently completed following direction contained in Forest Service Handbook (FSH) 7709.55 and provides detailed information on national forest system roads on the Forest. The purpose of the analysis was to:

- Identify key issues related to the Francis Marion National Forest transportation system, in particular affordability and cumulative effects;
- Identify benefits, problems, and risks related to the Forest's transportation system;
- Identify management opportunities related to the existing transportation system to suggest for future consideration as National Environmental Policy Act (NEPA) decisions such as changing road maintenance levels, decommissioning unneeded roads, addressing road-related resource risks, reducing management costs, and identifying and prioritizing watershed improvement needs through the Watershed Condition Classification Technical Guide (FS-978, 2011);
- Identify roads that are not currently needed or where the desired operational level differs from the current maintenance level as well as addressing instances where the desired operation level might be reduced, while maintaining access and services, with the recognition that as needs change, so can the desired operation level also be adjusted as long as they can be funded; and
- Develop a map to inform the identification of the future minimum road system (see definition in the next section).

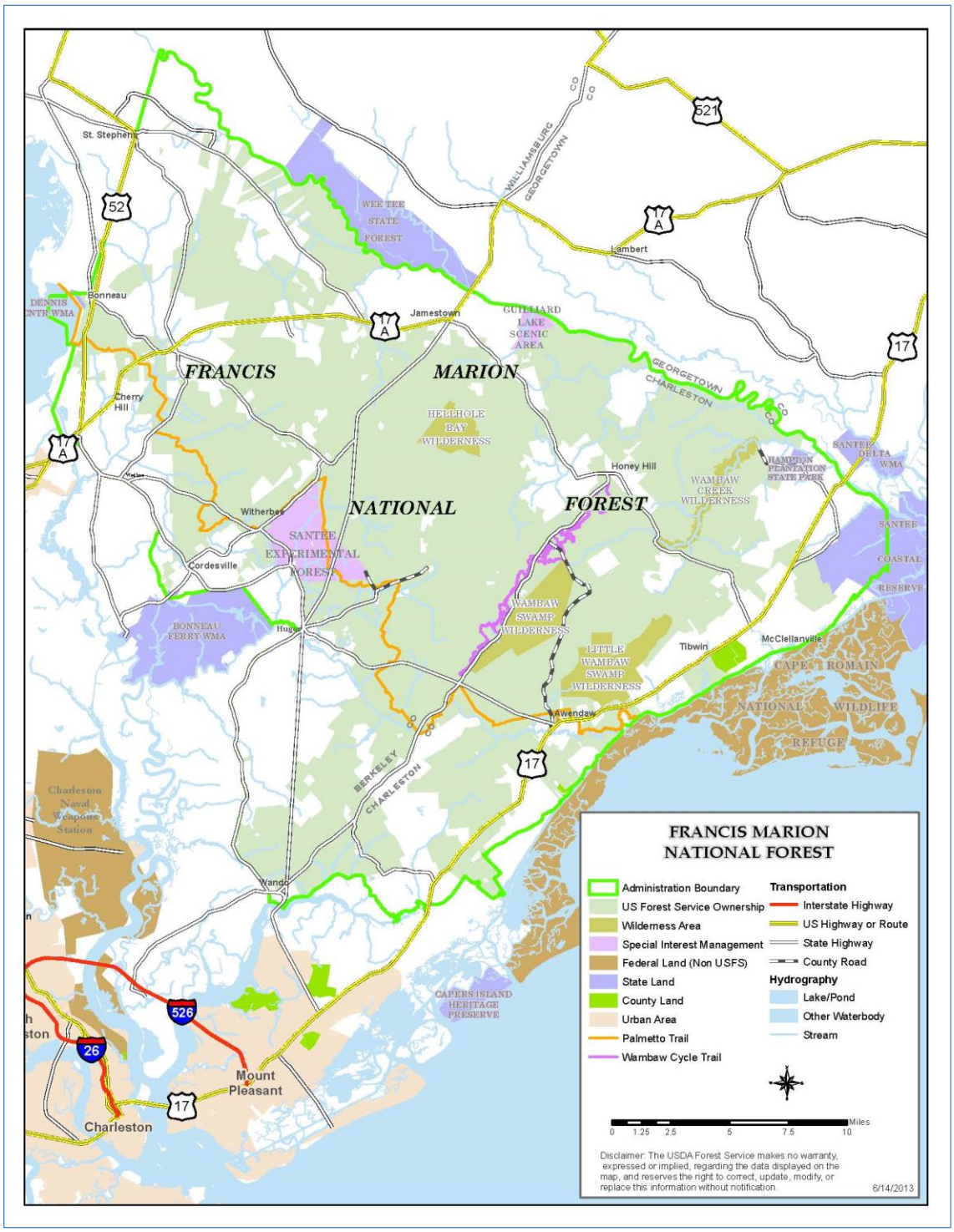


Figure 11-1. Major roads and trails on the Francis Marion National Forest

In November 2005, the Forest Service published a new travel management rule governing motor vehicle us on the national forests and grasslands. Under the final rule, the Francis Marion National Forest designated those roads and trails open to motor vehicle use. The motor vehicle use map is a requirement of the travel management final rule and displays those national forest system roads and trails that are designated open to motor vehicles by vehicle class (highway legal vehicles, high clearance vehicles, ATVs and motorcycles and any seasonal or time restrictions). The motor vehicle use map also provides information on additional travel rules and regulations and is reviewed annually to correct mapping errors, discrepancies and to reflect any changes in route status.

11.2.1.2 Current Conditions and Trends

There are approximately 576 miles of national forest system roads on the Francis Marion National Forest (Table 11-1). Efforts to maintain these roads are in accord with established road management objectives and are described by maintenance levels 1–5. Maintenance level 1 is custodial maintenance and corresponds to closed roadways that have periodic condition checks. Maintenance level 2 roads receive periodic condition checks and are maintained for passage by high clearance vehicles. Maintenance levels 3–5 have regular condition checks and are maintained for passenger vehicles at increasing levels of comfort and speed. Maintenance level 5 roads are typically paved.

Table 11-1. Miles of national forest system roads by maintenance level

Maintenance Level	Miles	Percentage
1	141.5	24.6
2	82.0	14.2
3	295.0	51.3
4	55.8	9.7
5	1.3	0.2
Total	**575.6**	**100**

The national forest road system is typically connected or tributary to Federal, state, and county road networks. Primary roads on the Forest include U.S. Highway 52; U.S. Highway 17; state routes 41, 45, and 17A; Halfway Creek Road; and Steed Creek Road.

There are also user-created roads on the Forest that are not a part of the Forest Service road system. It is common to find narrow dirt trails created by recent off-highway vehicle (OHV) use. These need to be decommissioned and closed upon identification. These illegal routes can cause damage to the National Forest including soil erosion, sedimentation to streams, damage to wetlands and wildlife habitat, and spread of invasive species.

Travel Analysis

A travel analysis was completed for the Francis Marion National Forest and the results are documented in the Transportation Analysis Process Report for the Francis Marion National Forest. The report identifies the risks and benefits associated with the current road system. A Forest interdisciplinary team used an analytical approach to evaluate risks and benefits associated with the Forest road system. The analysis was completed in a Microsoft Access database and is cross-referenced to a Forest road map. Ecological, social, and economic considerations relative to the Forest transportation system were evaluated consistent with publication FS-643–Roads Analysis: Informing Decisions about Managing the National Forest

Transportation System. A map was developed that displays the road system and can be used to inform project-level decisions for identifying unneeded roads and the minimum road system. This requirement is codified in the Code of Federal Regulations 36 CFR 212.5. It states, "The minimum road system is the road system determined to be needed to meet resource and other management objectives adopted in the relevant land and resource management plan (36 CFR part 219), to meet applicable statutory and regulatory requirements to reflect long term funding expectations, to ensure that the identified system minimizes adverse environmental impacts associated with road construction, reconstruction, decommissioning and maintenance."

Table 11-2 lists the risks and benefits associated with the Francis Marion road system evaluated by the interdisciplinary team.

Table 11-2. Draft Francis Marion risk/benefit criteria

Risk	Benefit
Motorized use present risks associated with these categories:	**Motorized uses benefit Forest management because they provide opportunities for these categories:**
Terrestrial plants and animals	Terrestrial plants and animals
Aquatic organism passage	Public infrastructure and incident management
Hydrologic modification	Vegetation management access
Sediment delivery	Recreation access
Nonnative invasive species	
Public safety/law enforcement	
Social setting impact	

All roads were individually rated by the interdisciplinary team members and data was summed to assign a numeric rating for each road. Each road generated a high, medium, or low rating based on the criteria stated in the previous section. Scores were based on a point system in which a high rating yielded three points, a medium rating yielded two points, and a low rating yielded one point. All scores were then summed into an overall risk and benefit rating. The results are shown in Table 11-3.

Forest-scale roads analysis has documented that funding for road maintenance is a concern. An annual need of approximately $3,041,000 per year has been identified as necessary to adequately maintain maintenance level 1–5 roads. This estimate is based on the average costs for maintaining these road levels. Appropriated funding for road maintenance is typically less than 25 percent of this amount, which has resulted in accumulating a large backlog of funds needed for road maintenance. The lack of adequate funds has profoundly affected road maintenance and access to national forest system lands. Road legacy funding is also available. The other major source of funding for roads continues to be from timber sales which typically have accounted for about $1,000,000 to $1,300,000 annually for both the Francis Marion and Sumter National Forests.

Table 11-3. Risk and benefit analysis of the Francis Marion National Forest road system

Criteria		Miles of Road						
Risk	**Benefit**	**ML-1**	**ML-2**	**ML-3**	**ML-4**	**ML-5**	**All Roads**	**Percent**
High	High	0	0	15.2	0	0	15.2	2.6
High	Medium	0	0	21.8	11.6	0	33.4	5.8
High	Low	0	1.1	0	0	0	1.1	0.2
Medium	High	2.6	0.2	22.9	26.5	1	53.2	9.2
Medium	Medium	8.8	22.2	195.2	17.4	0.2	243.8	42.4
Medium	Low	3.5	33.4	25	0	0	61.9	10.8
Low	High	17	4.8	1.2	0	0	23	4
Low	Medium	108.2	11.7	12.2	0	0	132.1	22.9
Low	Low	1.4	8.6	1.5	0.3	0.1	11.9	2.1
Total		**141.5**	**82**	**295**	**55.8**	**1.3**	**575.6**	**100**
Percent		**24.6**	**14.2**	**51.3**	**9.7**	**0.2**	**100**	

To date, no clear resolution has been reached to respond to the gap in funding road maintenance. Currently staff is working with Berkeley County to correctly identify and possibly increase the road mileage the county will maintain on national forest system lands through an updated cooperative road maintenance agreement. The desire is to complete this same process with Charleston County. Where the potential exists, the Forest Service is issuing Forest Road and Trail Act easements to respective counties for all road maintenance and management of specific roadways within the Forest.

The Forestwide transportation analysis process has determined the following:

- Existing funding is insufficient to maintain roads at their currently assigned objective maintenance level.
- Resource impacts are occurring from lack of sufficient maintenance.
- Most of the existing roads are needed for future management activities.
- Some roads are no longer needed for management and can be decommissioned.
- Objective maintenance levels can be reduced on some national forest system roads based on current and future needs.
- Road maintenance agreements with Charleston and Berkeley counties would help with needed maintenance on some national forest system roads.
- National forest system roads can affect cultural and traditional uses (i.e., forest product permits, special use permits, recreation and hunting and fishing access).

Area transportation plan development has been a part of timber management planning since the 1980s. Timber sales typically fund reconstruction and maintenance during the life of the sale. Other resource benefits are gained from this approach including addressing resource risks associated with roads and improved driving conditions on roads open to the public.

Approximately 13.7 miles of national forest system roads have been decommissioned since fiscal year 1999. Decommissioning has focused on reducing resource impacts and reducing management costs. It is becoming increasingly common for current management projects to have limited access to lands that previously received road decommissioning.

Several easements needed for the road system to clarify access rights to national forest system lands remain. Forestwide standards FW-127–FW-131 address the transportation system. These Forest standards should be deleted and described in desired condition statements for resource management areas. One standard should be developed to state that changes in road management objectives would be informed by the Forestwide transportation analysis process and any addendums.

Construction of new national forest system roads has been minimal since Hurricane Hugo in 1989. There are however, gains in some road mileages through the acquisition of tracts where roads pre-date national forest ownership. An example of this can be found in the Wando I'on tracts.

Water Condition Assessment

The water condition assessment has identified risk factors associated with roads for the 15 6th-level watersheds where national forest system lands comprise more than 5 percent of the watershed. Risks associated with roads include moderate to high open road densities, infrequent or inadequate road maintenance, proximity of the road to water and roads that are located on unstable landforms that cause mass wasting. Table 11-4 summarizes the results of the analysis for the 15 drainages.

Table 11-4. Watershed condition rating indicator for the 15 6th-level watersheds based on road attributes

Attribute	Good	Fair	Poor
Open road density	-	9	6
Road maintenance	-	-	15
Proximity to water	4	11	-
Mass wasting	15	-	-

High road densities indicate a high probability that the hydrologic regime is substantially altered. Open road densities are generally low on the Forest in the major 15 6th-level subwatersheds, ranging from a low of 1.52 miles of road per square mile of land on Gough Creek Watershed to a high of 2.52 miles per square mile of land on French Quarter Creek Watershed. Open road density on private lands is higher, which may be representative of the more intensive land use and development on private lands. Poor or infrequent maintenance indicates the potential for erosion or blocked or partially blocked culverts and ditches that can cause water to back up onto road surfaces or undermine the road surface. The number of miles of roads close to streams can cause pollution from road surfaces in the form of sediment and other contaminants, and can result in ditch lines that become hydrologically connected to streams. Roads on the Coastal Plain are typically elevated above the surrounding terrain and can act to restrict water movement across the road. This can constrain the riparian area or floodplain into an inadequate number or improper sized cross-drains, impacting the normal hydrologic function of stream, wetland, or riparian area. Landforms on the Coastal Plain by their very nature are stable, so this concern would only be relevant in a few, very specific circumstances.

The major 6th-level watersheds rated fair condition with impacts from road sediment not considered to be a large contributor. This is largely due to the well vegetated, flat terrain associated with the Coastal Plain. The main factors impacting watershed conditions include fecal coliform and mercury pollution.

Road management on the Francis Marion National Forest is moving toward a road system that:

1) Is more economical and sustainable,
2) Has less resource impacts,
3) Meets public needs,
4) Is adequate for continued management of the Forest, and
5) Improves or restores watersheds.

11.2.1.3 Information Needs

The transportation analysis process was completed and was used to inform the Forest plan assessment. It has identified benefits and risks associated with the national forest system transportation system and the information can be used in Forest planning and at the project level.

Roads have caused hydrologic modifications to streams, riparian areas, and tidal and non-tidal wetlands on the Forest. There is a need to get a complete assessment of all stream culverts and bridges as well as cross-drains. This information would help in identifying areas where wetland function has been impaired by roads. It would help in the development of an accurate stream layer in GIS that could be used to identify riparian areas. It would also identify where culverts are blocking aquatic organism passage as well as streams that have been diverted or made stream connections to upland and/or isolated wetland habitats. This information could be used to identify and prioritize restoration work for streams and wetlands to mitigate impacts from roads.

11.2.2 Trails

11.2.2.1 Existing Information

Existing relevant information regarding management of infrastructure can be described under several main areas including transportation (roads and trails); facilities (buildings and support systems); recreation facilities and special use authorizations. The following documents provide information and management direction regarding infrastructure:

- Forest Service Manual 7700 and 7710
- Inventory (Natural Resources Management System, Recreation Sites Inventory INFRA)
- Transportation analysis process (TAP)
- Forest Facilities Master Plan
- National Visitor Use Monitoring (NVUM)

11.2.2.2 Current Conditions and Trends

There are several types of trails on the Forest including equestrian, OHV, hiking, mountain biking, water, and interpretive. Mountain biking shares routes with a portion of the Palmetto Trail, Wambaw OHV trail, and both Jericho and Tuxbury horse trails (2008 Forest Plan Review).

There are approximately 177 miles of national forest system trails on the Francis Marion National Forest (Table 11-5). Efforts to maintain these trails are in accord with established management objectives.

Table 11-5. Forest trail mileages by designation

Trail Type	Miles
Hiking (includes biking)	68
Canoe/kayak	35
Equestrian	38
Off-highway vehicle	36
Total	**177**

Much of the analysis required to identify the minimum trail system has been accomplished through a series of plans, assessments, and analyses as summarized.

Several new national forest system trails have been established since the 1990s (including Tuxbury, Awendaw Passage of Palmetto Trail, and canoe trails). The new planning regulations emphasize improving the transportation system with clearly articulated desired condition statements and fewer Forest plan standards.

Forestwide travel management direction addresses off-road use and complies with the National Travel Management Rule (36 CFR 2112, Subpart B–Designation of Roads, Trails and Areas for Motor Vehicle Use, November 2005). This rule allows users to be notified to stay on designated trails.

Issues associated with various trail management include off-trail use and creation of non-designated trails, litter and damage to wetlands and stream channels.

11.2.2.3 Information Needs

Complete to update and create trail atlas for the district to depict trail conditions, maintenance needs, and mileages.

11.3 Structures

11.3.1 Facilities–Non-Recreation

11.3.1.1 Existing Information/Current Condition and Trends

The Francis Marion currently manages more than 48 buildings, an infrastructure which has been reduced by approximately 8 buildings in the last 5 years. This reduction is due to the sale and conveyance of three government-owned residences and an office/work center facility with associated buildings. Consolidation, co-location, a need to divest of government-owned residences, and a reduction in personnel has contributed to this decrease. The workforce on the Francis Marion is approximately 44 persons and may increase seasonally with temporary hires. All employees report to the new Francis Marion office in Huger, with work center facilities currently at Witherbee and Seed Orchard. Several of the facilities identified in Table 11-6 are identified as cultural sites and obtained through the acquisition of properties throughout the Forest (such as Walnut Grove).

Table 11-6. Non-recreation facilities

Location	Facility	Facility Type/Use
Awendaw Work Center	Storehouse	Other
Walnut Grove	House	Other
	Barn	Other
Honey Hill	Fire tower	Service
Oak Corner	Relay station	Comm Site
South Tibwin	Dwelling	Housing
	Bunkhouse	Barracks
	Shed	Storage
	Dwelling well house	Industrial
North Tibwin	Dwelling	Other
	Cabin	Other
	Barn	Other
	Horse stable	Other
Witherbee	Dwelling A (temporary office)	Housing*
	Dwelling B (602)	Housing*
	Dwelling C (603)	Housing*
	Dwelling D (604)	Housing*
	Dwelling E (605)	Housing*
	Storage dwelling 602	Storage*
	Storage dwelling 603	Storage*
	Storage dwelling 604	Storage*
	Storage dwelling 605	Storage*
	Ranger station (office)	Office
	Work center	Service
	Oil and paint storage	Storage
	Pole shed	Storage
	Radio relay station	Comm Site
	Witherbee Lookout Tower	Service
	Pumphouse/reservoir	Industrial
	Chemical storage	Storage
	Well house	Industrial
Seed Orchard	Office and lab	Office
	Oil/paint house	Storage
	Well house	Industrial
	Metal tool storage	Storage
	Metal equipment storage	Storage
	Chemical building	Storage
	Pole shed	Storage
	Seedling cooler shed	Storage
	Equipment shed	Storage
	Greenhouse	Other
	Block building at tower	Comm Site
Seed Orchard	Wood storage building	Storage

Location	Facility	Facility Type/Use
Helibase	Concrete building at tower	Comm Site
	Office	Office
	Well house	Industrial
FM Office	Office	Office
	CXT oil/paint house	Storage

* Decommission of these facilities is anticipated.

Listed for Decommission. Declining budgets and workforces are leading to needed administrative infrastructure reductions; however, the building boom of the 1960s means more buildings are considered heritage structures, making disposal more difficult. Along with trends to reduce the workforce, traditional work center "shops for equipment repair", colocation of employees, and very limited (or no) need for remote housing, there are opportunities to evaluate further infrastructure from the Forest.

The Forest Service is making efforts to reduce the carbon footprint by making more buildings efficient and sustainable. In 2011 the new Francis Marion office was constructed and certified as LEED Gold. This new facility replaced the need for two ranger station offices that formerly housed the employees of the Forest. Currently, one of the former facilities (including a work center) has been sold and removed from our needs for maintenance and upkeep.

According to the Energy policy Act of 2005, the Federal government is to reduce utility and operations costs 2 percent annually from 2006 to 2015. Any new buildings are to be designed to 30 percent below ASHRAE standard of International Energy Code if life-cycle cost-effective and/or LEED Silver standards.

Forest Service buildings and utilities are governed by the International Building Codes, the Architectural Barriers Act (Accessibility), State Water Protection regulations, National Historic Preservation Act of 1966 and various energy regulations. In addition, state and local codes may be applicable to the operation of Forest Service buildings.

11.3.1.2 Information Needs

Information concerning historic acceptability of existing condition for Forest Service buildings is needed; especially those buildings that became 50 years old between 2009 and 2020. The Forest facility master plan needs to be updated to reflect desired future conditions and to determine maintenance objectives according to regional guidelines. INFRA needs to be updated as necessary to reflect needs and changes. The Forest needs to develop a means to record carbon footprint data for all facilities.

11.3.2 Facilities–Recreation

Refer to section 11.6.2 "Facilities–Recreation" for information on sustainable recreation

11.3.2.1 Current Condition and Trends

The Francis Marion National Forest has over 20 recreation facilities (Table 11-7). This does not include associated fee tubes, kiosks, and information boards. Most facilities (about 70 percent of the facilities) meet the national standards. To meet national standards, the facility condition index (FCI) of a facility must be greater than 90 percent. FCI is the current value of the resource divided by the current deferred maintenance.

Many minor recreation sites are identified as dispersed sites. These dispersed sites were generally improved for resource protection rather than user convenience. Many of these sites have been improved, but much of the maintenance has been deferred. These sites have a maintenance level 0–2.

Table 11-7. Recreation facilities by location

Location	Facility	Facility Type/Use
Wambaw Cycle Trailhead	Shelter	Service
	Block SST	Service
	Well house	Industrial
Buck Hall Recreation Area	Shelter	Service
	Flush toilet	Service
	Bath house	Institutional
	Well house	Industrial
Sewee Visitor Center	Picnic shelter	Service
	Pergola	Service
Elmwood	Well house	Industrial
	Double CXT vault toilet building	Service
Honey Hill	CXT vault toilet building	Service
Canal	(2) SST Bldg[1]	Service
Canal	Picnic shelter	Service
Twin Ponds	Rifle range shelter	Service
Boggy Head	Rifle range shelter (#672)	Service
Huger	Picnic area CXT vault toilet building	Service
	Boat landing CXT vault toilet building	Service
	Picnic shelter	Service
	Well house[1]	Industrial

[1] Decommission of these facilities is anticipated.

The Forest receives annual funding to maintain recreation facilities. This funding has fluctuated over the past years, and appears to be declining. In addition to a yearly allocation of funds for facilities maintenance, the Forest competes for capital improvement funding to improve and/or develop recreation facilities. There are two sites on Forest that are managed as fee sites under the Recreation Enhancement Act (Buck Hall Day Use/Campground and Wambaw Cycle Trail/Trailhead. There is an opportunity to use a portion of fees collected at these two sites to enhance appropriated and capital improvement funds. There is also an opportunity for counties to request Title II funds from the Forest Service to improve recreation facilities.

Table 11-8. Recreation facilities by use

Type	# Facilities	Facilities W/Fee	Reservations	Total
Campgrounds	3	1	1	3
Visitor Center	1	--	--	1
Picnic/Day Use			--	
Boat Launch	4	1	--	4
Trailheads				
Interpretive Sites	2	--	--	2
Fishing Sites				

Most visitors to the Forest utilize some kind of recreation facility. The majority of visitors hunt, fish, camp, or use a trailhead or visit an interpretive facility. All of these activities involve the use of recreation infrastructure. Visitors who participate in these activities generally visit adjacent and local communities and therefore contribute to the local economy in various ways (food, lodging, fuel, supplies).

11.3.2.2 Information Needs

- Final national visitor use monitoring report (NVUM)
- Spatial data for developed and dispersed sites
- Recreation facilities analysis
- Continually monitor Forest facilities to determine ability to document and decommission as appropriate.
- Monitor budget trends to determine what portion of appropriated funds are available for facility maintenance. Consider alternate financing such as CIP or grants to meet needs.

11.3.3 Bridges (Roads and Trails)

11.3.3.1 Current Condition and Trends

There are 32 road bridges on the Forest maintained and managed by the national forest. These bridges get inspected every 2 years, and will need to be inspected in the fall of 2013. There are tentative plans to replace nine bridges because they are nearing the end of the expected life span.

There are 23 trail bridges on the Forest located on designated trails. These bridges are managed and maintained by the national forest. Bridges over 20 feet in length are considered complex and major structures and inspected every 4 to 5 years. There are currently no plans for replacement of these trail bridges.

Table 11-9. Forest road bridges

Forest Road Number	Operational Status	Year Built
212	Open	1965
202	Open	1965
251h	Open	1966
251h	Open	1966
204	Open	1968
159	Open	1968
159	Open	1968
159	Open	1968
159	Open	1968

Table 11-10. Forest trail bridges

Trail Bridge Name and Location	Trail Number	Trail Name
Cane Gully @ Mp 0.1000	260a	Swamp Fox/Palmetto Trail
Wadboo @ Mp 0.1900	260a	Swamp Fox/Palmetto Trail
Canal Rec Area @ Mp 0.2000	260a	Swamp Fox/Palmetto Trail
Turkey Creek @ Mp 0.3000	260a	Swamp Fox/Palmetto Trail
Little Hell Hole @ Mp 0.4000	260a	Swamp Fox/Palmetto Trail
Steed Creek @ Mp 0.7000	260a	Swamp Fox/Palmetto Trail
Boy Scout Bridge @ Mp 0.8800	260a	Swamp Fox/Palmetto Trail
Palmetto Trail/Swam @ Mp 10.0000	260a	Swamp Fox/Palmetto Trail
20' Bridge Palmetto @ Mp 10.1000	260a	Swamp Fox/Palmetto Trail
Harleston Dam @ Mp 10.2100	260a	Swamp Fox/Palmetto Trail
Palmetto Tr. Ext #1 @ Mp 3.4000	260a	Swamp Fox/Palmetto Trail
Palmetto Tr. Ext #5 @ Mp 4.0000	260a	Swamp Fox/Palmetto Trail
Palmetto Tr. Ext #7 @ Mp 5.0000	260a	Swamp Fox/Palmetto Trail
Halfway Creek @ Mp 6.1900	260a	Swamp Fox/Palmetto Trail
Sewee Boardwalk @ Raptor @ Mp 0.0000	268	Sewee Raptor Trail
Sewee Redwolf Boardwalk @ Mp 0.0000	270a	Nebo Trail
Sewee Pond Bridge @ Mp 0.0000	270b	Red Wolf Enclosure Spur
Horse Trail #3 @ Mp 1.0000	370	Jericho Horse Trail
Horse Trail #2a @ Mp 1.0000	370	Jericho Horse Trail
Horse Trail #4 @ Mp 1.8000	370	Jericho Horse Trail
Horse Trail #1 @ Mp 10.5000	370	Jericho Horse Trail
Horse Trail #2 @ Mp 11.7000	370	Jericho Horse Trail
Greentree Reservoir-Horse Trail #5 @ Mp 3.0000	370	Jericho Horse Trail

11.3.3.2 Information Needs

Continued monitoring of budget trends to evaluate priorities for trail bridge replacement or decommission.

12 Federally Recognized Indian Tribes

Federally recognized Indian tribes and government-to-government consultation was not addressed in the 1996 land management plan. The Forest Service 2012 Planning Rule states that in the assessment for plan development or revision, the responsible official shall identify and evaluate existing information relevant to the plan area for areas of tribal importance.

12.1.1.1 Introduction

The Catawba Indian Nation, located near Rock Hill, South Carolina, is the only federally recognized Indian tribe with connections to the plan area. The Catawba are a confederation of many different Indian peoples from North and South Carolina. Native peoples were devastated by Old World diseases to which they had no natural immunities. Others were enslaved by European colonists or were displaced by warfare. The Catawba joined with the Yamassee and other Indian groups during their revolt against the South Carolina colonist between 1713 and 1715. After their defeat many of the native peoples of the Lowcountry moved to the upper piedmont of South Carolina and took refuge with the Catawba. This led to an amalgam of linguistically diverse populations and the formation of a powerful native alliance that became the Catawba Nation.

While most Indian people fled the Lowcountry there were groups of Indian peoples that remained. Many of their descendants still live in communities throughout the Lowcountry and have come together to be recognized by the State of South Carolina and form State-recognized tribes. However, none of the State-recognized groups live within the Forest area. There is little to distinguish the Catawba or members of the State-recognized tribes from other Americans living in the State (Hudson 2007, page 3).

12.1.1.2 Existing Information

Given the distance between the Catawba Nation and the Francis Marion National Forest there has been little interaction, visitation, or use of the Forest by the Catawba or other Indian peoples (this is not to say that there is no interest in the Forest by Indian people). Unlike North Carolina where Cherokee traditional practitioners come to the Forest to gather forest products for use or to visit sacred sites, there is no record of active use of the Forest by the Catawba or other people of Indian descent. This is due mainly to the fact that there has not been a significant Indian presence since the Yamasee War ended in 1716. Most of the local Indian people were either captured or removed, or they moved away from the area seeking refuge with the Catawba. A few small communities remained in the Lowcountry, but none are found on or adjacent to the Forest.

12.1.1.3 Current Condition and Trends

The Forest currently consults with the Catawba Indian Nation as part of its project review under the National Historic Preservation Act. However, there are no other agreements or partnerships.

The Catawba Indian Nation is committed to conserving their culture and its connection to the land. They are particularly interested in locating natural clay deposits which they use to create native ceramic vessels and objects. Sources near their reservation are not always accessible and suitable clay from the Forest area would help to maintain this important cultural craft industry. However, the distance between the where the majority live and the Francis Marion National Forest makes it impractical for them to use this resource even if there were a source on the Forest.

The Catawba River is a source of spirituality and provided transportation, food, and drink for hundreds of years. The river remains central to Catawba life, but having access to clean water is also a source of deep concern as development, agriculture, and timber harvesting have degraded the quality of the water. Again the physical separation between the residents and the Forest make this impractical.

12.1.1.4 Information Needs

The Forest needs to determine what issues may be culturally important to Indian tribes. These include such things as:

- Are there traditional cultural places or sacred sites or sacred places within the Forest?
- What resources are traditionally and culturally important to the tribe?
- Are there project activities of concern to the tribe within the Forest?
- How is confidentiality of cultural sensitive information protected?

The South Atlantic Landscape Conservation Cooperative in Raleigh, North Carolina, met with key stakeholders, including the Catawba, to assess their interests and needs. Their goals were to share information on how to connect, facilitate, and develop positive partnerships and to promote the preservation of traditional ecological knowledge. They found that the tribe was committed to conserving their culture and its connection to the land. They learned that the tribe is particularly interested in sources of clay deposits that would be suitable for use in the making of pottery. Handmade pots are an important cultural link to their past and an important economic craft industry as well. The Forest Service needs more time to consult with the Catawba to determine their interests in the Forest and how might the Forest and its resources help satisfy their needs.

13 Cultural and Historic Resources and Uses

13.1.1.1 Preliminary Findings

The 1996 Forest plan had a goal of protecting cultural values, but the statement is too broad to be meaningful because there are no Forest objectives specific to cultural resources. The standards and guidelines are inadequate, focusing only on meeting a limited number of the full range of legal requirements. Under the current land management planning regulation (36CFR219.2(a)) forest planning should:

1. Provide an overview of known data.
2. Identify areas requiring more intensive inventory.
3. Provide for evaluation of sites for National Register listing.
4. Provide for protection of significant cultural resources.
5. Identify maintenance needs for historic properties.
6. Identify opportunities for interpretation of cultural resources.
7. Examine the potential for interaction between cultural resources and other Forest uses (36CFR219.2(b)).
8. Coordinate with State historic preservation plans and the plans developed by other Federal agencies (36CFR219.2(c)).

The current plan called for the evaluation of cultural resources and the nomination of eligible sites to the National Register of Historic Places. There is an implied need to protect significant cultural resources, but the 1996 plan only articulates this as a specific goal for special areas within management area 8.

In the late 1990s the Forest implemented an effective monitoring program to compare existing cultural resource conditions to the desired conditions. Emphasis was placed on monitoring priority heritage assets, a subset of all cultural resources. Priority heritage assets are significant cultural resources whose management priorities are recognized through prior investments in preservation, interpretation, and use. Presently there are approximately 2,390 cultural resources on the Forest, of which 6 are considered priority heritage assets. Given the large number of cultural resources located on the Forest a sampling strategy is used to select a subset of historic properties for monitoring. This subset consists of priority heritage assets and other historic properties.

The following findings are presented in terms of how well the Forest is meeting the existing plan direction and the heritage program national strategy.

Land Management Activities. The Forest recognizes its obligation to abide by legal policy and Forest Service direction to protect significant cultural resources. The primary focus has been on avoiding impacts to cultural resources during project implementation. A review of annual monitoring reports from 2000 through 2011 found that eight archaeological sites were disturbed by various Forest management activities.

Forest Users. Vandalism and threats from Forest users is a serious concern. A review of annual monitoring reports from 2000 through 2011 found that at least 22 sites were damaged by

unauthorized activities such as the use of woods roads, use of off-highway vehicles outside of designated trails, and the creation of unauthorized hiking and horseback riding trails. Often the damage was unintentional as users were unaware of the effects of their actions. However, the full scope of deliberate acts such as archaeological site looting and vandalism is not known due to the small sample of sites monitored. However, it is clear that the use of metal detectors to dig for relicts on historic sites is a continuing problem.

Natural Deterioration and Deferred Maintenance. The passage of time degrades the structural integrity of the buildings and other structures. Threats to historic buildings and structures are a serious concern and the Forest has taken modest steps to address some of the deferred maintenance needs for historic properties including the North Tibwin House and Walnut Grove House. The Forest has successfully developed partnerships with various institutions and organizations with the technical expertise to address some of the deferred maintenance needs. However, existing deferred maintenance needs have not been adequately addressed to prevent the reduction in structural integrity of historic buildings and lookout towers.

Environmental Threats. Natural threats, such as erosion, have damaged some archaeological sites; however, damage is not widespread. Natural threats are mostly confined to those cultural resources located adjacent to the Atlantic Intracoastal Waterway. Wave action by boaters on the Intracoastal Waterway is the most serious immediate threat. Long-term threats come from the potential for catastrophic storms and the continued rise in sea level.

National Register Evaluation and Listing. The Forest continues to evaluate cultural resources for their eligibility for listing in the National Register of Historic Places as part of historic property identification efforts in support of other resource activities. However, the Forest has not reduced the archaeological site evaluation backlog due to insufficient funding to support such a costly and labor intensive effort. The Forest's emphasis is on meeting NHPA and NEPA compliance in support of other resource management activities.

Partnerships and Public Participation. Through the years the Forest implemented a number of successful partnership programs with various academic institutions and other interested organizations. These programs not only encouraged public participation, but the Forest was able to achieve results not possible with Forest staff and funding alone. Cultural resources which benefited from these activities include Battery Warren, North Tibwin House, the old Awendaw Work Center, and the Sewee Shell Ring.

Cultural Resource Interpretation. Interpretation is another area where the Forest saw some success. Two sites, Sewee Shell Ring and Battery Warren, have well developed trails and the Forest conducts public education programs and promotes resource stewardship. The interpretive trails help the Forest visitor understand and appreciate these and other sites on the Forest. However, the Forest faces challenges in developing new and improving existing interpretation.

Fiscal Constraints. Budget limitations constrain the ability to reduce deferred maintenance issues associated with historic property management and/or employ enhancement activities meant to bolster the integrity and understanding of the resource. Funding, time, and staffing constraints limit the number of sites evaluated for the National Register of Historic Places. No sites have been nominated to the National Register.

Changes in Legal Requirements. Since 1996, there have been changes to historic preservation law, new Executive orders, and initiatives establishing Federal policy. Preserve America Executive Order 13287 encourages Federal agencies to seek partnerships to make more efficient

and informed use of these resources for economic development and other recognized public benefits [www.preserveamerica.gov].

Since the implementation of the 1996 plan, there have been changes in Federal law and regulation, with new manual and handbook direction (FMS 2360 and FSH 2309.12). These new tools provide the official legal policy and direction for Forest and line offices to meet heritage program standards. The 1996 land management plan was written prior to the implementation of the Forest Service's National Heritage Strategy for the management of cultural resources. The three principal goals of the strategy are to protect significant cultural resources, to share their values with the American people, and to contribute relevant information and perspectives to natural resource management. The strategy gives specific direction for forest land management planning including the development of goals and objectives, standards and guidelines, management area direction, land suitability in light of cultural resources, and cultural resource monitoring requirements.

13.1.1.2 Introduction

This guidance is considered in the development of the assessment write-up on cultural resources:

- Requirements in the planning rule.
- Evaluate existing information: social conditions, trends, sustainability and relationship to Forest plan in context of broader landscape.
- Consider existing and future conditions and trends.
- Assess sustainability of social, economic and ecological systems.

The Forest Service provides leadership in preserving America's heritage through responsible stewardship activities that recognize, preserve, protect, enhance, and use cultural resources for the greatest public benefit. In addition to identifying, monitoring, and protecting cultural resources, the Forest Service provides opportunities for the public to understand, enjoy, and appreciate their heritage within the national forest. To achieve these goals, cultural resource specialists provide information relevant to land use planning, research, public interpretation, and conservation education.

13.1.1.3 Existing Information

Information for this cultural resources assessment comes from multiple sources including the Forest Service's Natural Resources Management IWeb database, the Forest's geographic information system (GIS), cultural resources overview, and cultural resource inventory and evaluation reports. Annual land management monitoring reports and documentation from cultural resource condition surveys provided information on recent conditions. Together these various sources of information help to identify changed conditions within the plan area.

The prehistoric culture history of a region is usually presented as a chronological sequence of developmental or evolutionary stages. The earliest widely recognized period, the Paleoindian Period, began sometime around 12,000 years ago. Paleoindian adaptations appear to have been characterized by focal large-game hunting economies, low population densities, and large territorial ranges. The succeeding Archaic Period exhibits a gradual shift toward hunter-gatherer adaptations involving the exploitation of secondary resources (i.e., nuts, seeds, greens, fish, shellfish, etc.). Territorial ranges appear to have contracted and population levels are thought to have increased. The following Woodland Period saw the development of horticulture and other intensive forms of subsistence technologies and provided the basis for semi-sedentary and

sedentary village life. Population levels were greater than those of the Archaic and territorial ranges continued to contract. The final prehistoric period in the Southeast is known as the Mississippian Period. Mississippian groups were characterized by sedentary village life, intensive corn agriculture, regional chiefdom societies, and platform-mound ceremonialism. These cultures rapidly declined with the entry of the Spanish and other Europeans in the sixteenth and seventeenth centuries.

The British Crown began open competition with Spain to settle the southeastern United States in 1629. This land was initially referred to as Carolana. After the Restoration in 1660, a group of noblemen who eventually put a claim on King Charles II to grant them possession of the province of Carolina in 1663 (Edgar 1998, page 39). These were the Lord's Proprietors and they held rights to make war and peace, establish towns and ports, to raise and maintain armies, collect taxes and duties, to impose penalties, grant pardons, and grant "title of honors." It was not until 1669 that the Lord's Proprietors decided to take an active role in the colonization. One of the Proprietors, Lord Ashley, took the lead in this endeavor and supplied three ships for 100 English men and women to immigrate to Carolina. Because land was scarce, the colony quickly attracted settlers from the West Indies, particularly Barbados.

The settlement of Charles Town, named after the king, soon took shape. A steady influx of new settlers was drawn from a diverse European population. Included in the mix besides the English were, in order of popularity, Scots, Irish, Welsh, German, French, Dutch, and Swedish settlers. The early French settlers were Huguenots, who first immigrated in 1680, fleeing religious persecution. Many of the Huguenots settled locations north of Charleston along the Santee and East Branch of the Cooper River and became successful rice planters. Planting, in fact, served as the impetus to move away from Charles Town and out into the countryside along the major rivers (Kovacik and Winberry 1987, page 69). Land was variably fertile and the first plots settled were the "Indian old fields" formerly cultivated by the native population.

Owing to its deep harbor, Charleston rapidly became a major port city in the Americas and an influential and wealthy mercantile class emerged. The early export economy was driven by Indian trade, in particular the deerskin industry (Kovacik and Winberry 1987, page 69–70). Approximately 64,000 skins were exported annually to England at the end of the seventeenth century (Edgar 1998, page 136). Other important industries at the end of the seventeenth century included naval stores (i.e., pine pitch, rosin, and turpentine), lumber, and livestock. Naval stores products were used in the shipbuilding industry, but export levels reached a premature ceiling due to England's reluctance to buy the products. Nevertheless, by 1720 South Carolina had become the leading exporter of naval stores in the Empire (Edgar 1998, page 139). By the 1740s, this industry was well in decline. However, because the rice industry was so profitable, that labor could not be sacrificed to produce tar and turpentine. The main market for pine and cedar planking and shingles was the West Indies. The lumber industry maintained viability throughout the Colonial period. Barreled beef and pork were also exported in great quantities to the West Indies (Kovacik and Winberry 1987, page 71).

The agricultural industry was slow to develop beyond subsistence farming. Sugar cane was unsuccessfully grown, as were a number of other tropical crops grown in the West Indies. Rice ultimately became the main cash crop of the colony. In the earliest years, it was only grown on dry sites, but planters gradually developed techniques to allow them to grow it in freshwater upland swamps, which greatly increased production and profits. These early rice plantations were built on the backs and experience of West African slaves, who were quite proficient in clearing swamps, building dikes, and preparing rice seeds for planting.

Settlement outside of Charleston continued throughout the eighteenth century. A section of the James Cook map of 1773 shows the extent of this migration into the area in and around the Forest just prior to the Revolutionary War. The Cook map is the most detailed and accurate map of the period (Cumming 1958, page 254). Especially evident are the line of plantations between Georgetown Road and the coast in Christ Church Parish and the Huguenot residences along the lower Santee River. Dwellings ranged from impoverished shelters that were called "potato houses" to refined mansions (Edgar 1998, page 201). Potato houses were made of branches and dirt and were generally constructed to provide temporary shelter during the initial stages of settlement. The settlements depicted by Cook were likely more substantial. Rudimentary domestic structures consisted of dirt-floored, single room log cabins, sturdier hewn-log cabins, and wood frame houses. Finer homes consisted of either wood frames or brick walls and mimicked English floor plan styles, particularly central halls with flanking rooms. Many of the planters throughout the backcountry also had finer residences in Charleston. Enslaved Africans were generally charged with constructing their own dwellings. Consequently, they generally followed West African traditions (Ferguson 1992). These houses were small and made of wattle and daub or hand-made clay brick. Thatched roofs were steep to promote drainage.

The Lowcountry figured prominently in the Revolutionary War (Kovacik and Winberry 1987, page 84–85). Charles Town was attacked by the British in June of 1776, who met with stern resistance and they were forced to withdraw. Charles Town served as an important link in the continental supply system thereafter. Rice and indigo were exported to the French West Indies to finance supplies for the war. However, not everyone in the colony sympathized with the patriots. A large faction of Tories occupied the backcountry, but the British were not adept at mustering their support (Lambert 1987). In 1780, the city was captured. Resistance to the British occupation of the colony was primarily conducted as guerilla warfare during the occupation. One of the most famous partisan leaders was Francis Marion, who launched attacks against the British from his stronghold in the swamps around Charles Town. The British did not withdraw from the colony until 1782. The colony had sustained a great deal of destruction during the War. Plantations had been destroyed and nearly 30,000 slaves had vacated.

The destruction wrought by the war actually stimulated the development of tidal rice cultivation in the Lowcountry (Edgar 1998, page 266–267). This technique required a much greater capital investment than traditional inland swamp fields due to the need for extensive dam and dyke systems. Tidal rice cultivation produced five to six times the rice per enslaved worker and this fact quickly transformed the agricultural landscape of the Lowcountry. Many of the inland swamp plantations were abandoned. By 1839 South Carolina produced three-quarters of the rice in the United States. Mills' 1820 map of Charleston District shows that very little change had occurred in the area of the Forest since the Cook map was drafted. However, it is interesting to note that the routes of the major roads used today were already established by the 1820s.

The first skirmish of the Civil War occurred in 1861 when Confederate gun batteries opened fire on Fort Sumter in Charleston Harbor. The tensions that had initially emerged during the formation of the Union over slavery ultimately led to the secession of the Southern States.

The Civil War ended the plantation system throughout the South. The agricultural economy of the Lowcountry declined and was replaced by small subsistence farms, phosphate mining, and timbering. The average farm size in South Carolina in 1880 was 143 acres, a fourfold reduction from the 1860 average (Kovacik and Winberry 1987, page 106–107). The Union supplied very little help to the freed slave population, which ultimately returned to farming through a new system of farm labor called tenancy. Settlements became widely scattered across the Lowcountry

rather than being aggregated at plantation sites. Post-bellum agriculture was primarily focused on cotton and corn production. In the twentieth century, tobacco and soybeans also became important crops. All of these crops, with the exception of tobacco, were more productively grown in the upstate than in the Lowcountry.

Timbering activities shifted from the Great Lakes region to the South in the late nineteenth century (Hester 1997). Industrial timbering companies purchased large tracts of land, built mills, and commenced lumbering vast timber stands in the Southern pine belt. By 1918, in spite of cooperation with government foresters, private timbering companies had nearly depleted mature stands of trees. The Clarke-McNary Act of 1924 allowed the Federal government to acquire lands for the purpose of timber production. In 1928, the National Forest Reservation Commission approved the purchase of two tracts of land in South Carolina, a 75,000 acre tract on the Sampit and Black Rivers and the Wambaw purchase unit corresponding to the modern area of the Francis Marion National Forest. Most of the Wambaw unit, which consisted of about 100,000 acres, was held by the North State, Atlantic Coast, Dorchester and Tuxbury lumber companies. Purchase of the Wambaw unit finally occurred in 1933, resulting in the formation of Francis Marion National Forest. Most of the original facilities and roads associated with the Forest were built by the Civilian Conservation Corp in the 1930s.

All cultural resources are, to some degree, important. Site locations can help in understanding past human land uses over time. However, depending on their conditions and other factors, not all cultural resources are managed as significant historic properties. Site significance is usually defined in terms of eligibility for listing in the National Register of Historic Places. Historic contexts, similar to culture histories, are written to develop research questions or define characteristics used to evaluate their eligibility to the National Register.

In 1996, there were approximately 1,345 archaeological sites recorded on the Francis Marion along with three historic buildings and two historic fire lookout towers. Of these cultural resources, the Sewee Shell Ring was listed on the National Register of Historic Places. The Forest Service, in consultation with the South Carolina State Historic Preservation Office, determined that 23 archaeological sites were eligible for listing in the National Register, 861 were not eligible for listing and the remaining 415 sites were unevaluated.

As of 2013, there are more than 2,300 archaeological sites, 4 historic buildings, and 2 historic fire lookout towers recorded on the Francis Marion National Forest. However, the Sewee Shell Ring remains the only site listed on National Register. Approximately 59 sites are eligible for listing while 1,297 cultural resources remain unevaluated, but they are managed as if they were eligible for listing in the National Register. The remaining 943 cultural resources are ineligible for the National Register and are not actively managed by the Forest.

Priority heritage assets are those heritage assets of distinct public value that are or should be actively maintained and meet one or more of the following criteria:

1) The significance and management priority of the property is recognized through an official designation; e.g., listing on the National Register of Historic Places, State register, etc.

2) The significance and management priority of the property is recognized through prior investment in preservation, interpretation, and use.

3) The significance and management priority of the property is recognized in an agency-approved management plan.

4) The property exhibits critical deferred maintenance needs, and those needs have been documented. Critical deferred maintenance is defined as a potential health or safety risk, or imminent threat of loss of significant resource values.

Should an asset meet any of these criteria, it is designated as a priority heritage asset. Of the 59 cultural resources eligible for or listed in the National Register, 6 are considered priority heritage assets.

Other heritage assets are cultural resources that may have potential important historical or cultural significance, but lack formal listing and demonstrated need for active maintenance. Examples include archeological sites in the general forest area that could provide data about past human occupation, but are not located in an area subject to disturbance. Also included would be historic structures that are in stable condition, not considered a multiple use asset and are not significant enough to warrant priority heritage asset status.

The Forest Service attempts to determine the National Register eligibility of each new archaeological site when it is initially recorded or revisited. Often there is not sufficient time and funding to complete a full evaluation resulting in an increase in the backlog of unevaluated sites.

13.1.1.4 Current Condition and Trends

The 1996 plan sets as a Forest goal the protection and management of cultural values in protected unique areas. Under the Forest standards and guidelines it directs the Forest to inventory, assess, protect, and nominate cultural resources to the National Register. It establishes management areas to ensure protection and preservation of cultural values and encourages visitation by the public. Currently, there is no change in conditions as the Forest is doing all of these with the exception of nominating historic properties to the National Register.

Changes in Science and Technology

Since 1996, several advances in technology led to a more complete understanding of the nature and location of cultural resources on the Forest. Improvements in computer processing led to the implementation of programs such as GIS. Through GIS we can visually display how sites are distributed across the landscape. It provides a technique for more sophisticated modeling of human adaptation to changing environments and climate through time. It can provide for a diachronic view that helps us to understand of where the nature and location archaeological sites on the Forest landscape at different times. Combined with the vastly improved GPS availability and accuracy, cultural resource specialists are better able to locate and map sites enabling better management of sites on the Forest.

We now know that human occupation of the Forest began much earlier and is more extensive than was known in 1996. It is clear now that changes in the climate led to changes in human occupation and exploitation across the Forest areas. The rise and fall in sea levels led to a collapse and then reestablishment of the local estuaries. This in turn forced local populations to adapt to new ecological conditions and a trend towards a more sedentary lifeway. By AD 800 to 900, the population exploded and people began to intensify exploitation of coastal resources. But by AD 1400 these highly intensified economic systems had depleted the estuaries which results in a subsequent depopulation of the region just prior to European contact and settlement (Cable 2013).

Cultural resources support to other program areas increased dramatically between 1996 and 2013. The greatest impact was the result of increased land management activities associated with timber harvesting. Activities related to timber management expanded as a result of the implementation of large scale analysis areas encompassing thousands of acres. As a result of legally binding agreements with the South Carolina State Historic Preservation Office (SHPO) and federally-recognized Indian tribes, the Forest implemented a more comprehensive approach for cultural resources activities in support of other resource management activities. This included the adoption of the Council of South Carolina Professional Archaeologists standards and guidelines.

Changes in Legal Requirements

Since 1996, there have been changes to historic preservation law, new Executive orders, and initiatives establishing Federal policy to provide leadership in preserving America's heritage by actively advancing the protection, enhancement, and contemporary use of the historic properties owned by the Federal government. Preserve America Executive Order 13287 encourages Federal agencies to seek partnerships with state, tribal, and local governments and the private sector to make more efficient and informed use of these resources for economic development and other recognized public benefits. In addition, it directs agencies to use existing authorities and resources to assist in the development of local and regional heritage tourism programs that are a significant feature of many state and local economies [www.preserveamerica.gov].

Since the implementation of the 1996 plan, there have been changes in Federal law and regulation, with new manual and handbook direction (FMS 2360 and FSH 2309.12). These new tools provide the official legal policy and direction for Forest and line offices to meet heritage program standards. The 1996 land management plan was written prior to the implementation of the Forest Service's National Heritage Strategy for the management of cultural resources. The three principal goals of the strategy are to protect significant cultural resources, to share their values with the American people, and to contribute relevant information and perspectives to natural resource management. The strategy gives specific direction for Forest land management planning including the development of goals and objectives, standards and guidelines, management area direction, land suitability in light of cultural resources, and cultural resource monitoring requirements.

Condition of Known Resources

Thousands of archaeological sites within the plan area have survived three centuries of extensive land modification. Agriculture was the primary source of wealth from the colonial period onward. The landscape was modified to accommodate the various cash crops; rice in the swamps and wetlands, various row crops in the dryer uplands. Livestock grazed in both the fields and forests.

The dawn of the twentieth century saw the introduction of intensive timber harvesting by large lumber companies throughout the plan area. The Forest Service acquired much of these former lumber company lands to form the core area that became the Francis Marion National Forest. Since the mid-1930s, the area was subject to decades of modern land management activities conducted by the Forest Service.

During the same period, the national heritage resources program sought greater accountability and visibility (National Heritage Strategy 1999). The result was the creation of a national heritage database to track all activities, both legal compliance support to other resources and heritage resource program activities. Greater emphasis on plan level monitoring of archaeological sites and historic buildings improved efforts to track and document administrative

and field procedures which provided information on sufficiency of Forest efforts to protect cultural resources. The heritage program developed new accomplishment measures as part of the national objective of a heritage program managed to standard. Together the new database and program measures created increased Forest accountability and heritage program upward reporting.

The 1996 plan included increasing the number of cultural resources listed on the National Register of Historic Places as a desired condition and objective. This objective was not met, and no additional cultural resources were nominated to the National Register. However, the number of cultural resources determined eligible for the National Register did increase.

Trends

A number of trends were identified that affect the condition of cultural and historic resources within the plan area.

Forest Users and Cultural Resources. Cultural resource assets within the Forest occur in rural settings which pose both challenges and opportunities. In a study by the National Trust for Historic Preservation, Lindberg and Halasinski (2005) found rural areas on the urban fringe, "… are experiencing population growth and sprawling development that threaten to eliminate the rural qualities that made them attractive to new residents in the first place." Some small, rural communities nestled within the Forest are in decline due to limited employment opportunities and economies shifting away from agricultural production. However, the trend for the Forest has been an increase in population growth and loss of green space which increases demands on the Forest for outdoor recreation opportunities. The most serious issue to emerge in the last decade has been an increase in vandalism and Forest user impacts to cultural resources.

Visitor impacts, particularly from dispersed and unmanaged recreation activities, continue to unintentionally impact sensitive cultural properties. Examples include unauthorized, user-created trails for off-highway vehicles, horses, bicycles, and hiking. Intentional visitor impacts include vandalism which has damaged three of the historic buildings and one of the historic fire lookout towers. Unauthorized and illegal excavation, metal detecting, and the removal of artifacts from sites by Forest visitors leads all lead to the loss of valuable scientific information.

Resource and Land Management. The area of the Forest has been subjected to a variety of land uses for over 300 years. Legacy activity impacts such as past land use and land management activities affected cultural resources prior to the establishment of laws and regulations meant to protect those resources. With the passage of time natural deterioration degrades the structural integrity of both archaeological sites and the built-environment (i.e., building and structures), degrades the composition of organic-based archeo-environmental data sets, and alters landforms which possess sensitive archaeological sites.

Current land management activities such as prescribed burning and wildland fire suppression can have significant adverse impacts on historic properties if not mitigated by actively avoiding and protecting these cultural resources. Wildland fire can destroy buildings and alter sensitive organic-based archeo-environmental data. Fire suppression activities using heavy equipment have an even greater potential to damage or even destroy archaeological deposits. Conflicting mission goals and objectives may minimize consideration of cultural resources. Thus, the goals and values of other resource programs may inadvertently hinder the Forest's ability to protect cultural resources eligible for the National Register of Historic Places.

Wildland fire can destroy built-environmental resources, and alter sensitive organic-based archeo-environmental data sets. Fire suppression activities using heavy equipment have an even greater potential to damage or even destroy archaeological deposits.

Natural Deterioration. The passage of time degrades the structural integrity of our built-environmental resources (i.e., building and structures), degrades the composition of organic-based archeo-environmental data sets, and alters landforms which possess sensitive archaeological sites.

Fiscal. Fiscal constraints and limitations affect the Forest's ability to reduce deferred maintenance issues associated with historic property management. Neglect of historic buildings and archaeological sites due to budget constraints threatens their integrity and the Forest's ability to preserve and protect cultural resources. As responsible stewards, the Forest cannot employ enhancement activities meant to bolster the integrity and understanding of the resource.

Budget limitations constrain the ability to reduce deferred maintenance issues associated with historic property management and/or employ enhancement activities meant to bolster the integrity and understanding of the resource.

Public Participation, Partnerships, Research. Likely, future trends include an increased demand for the preservation and enhancement of cultural resources to meet a growing demand for heritage tourism and public education. The number of people attending heritage programs and participating in heritage related events saw an initial increase from 1996. However, participation in heritage programs, such as Passport In Time and cost share partnerships, decreased due to declining heritage budgets and increased compliance workloads.

Heritage Tourism. According to the Travel Industry Association of America, visiting archaeological and historical sites is one of the top five reasons for traveling. People want to experience the Nation's history first hand. The Forest can create opportunities for visitors to gain an understanding of an unfamiliar place and well interpreted sites help visitors understand and appreciate their importance and strengthen the conservation message. Communities support cultural heritage tourism because it can have tremendous economic impact on local economies and enhance quality of life. Visitors have an expectation of a quality experience. However, successful promotion of historic and archaeological sites brings with it new challenges as an increase in the number of visitors can create problems for the very sites we seek to protect (National Trust for Historic Places).

The Forest Service can help to achieve these goals by ensuring public enjoyment of our Nation's heritage through greater knowledge and appreciation of cultural and historical resources. There is general agreement that the potential of cultural and historical resources to contribute to heritage tourism and education is underutilized and should be improved, and one way is to consider more effective ways to encourage outcomes that better use archaeological resources to promote heritage tourism.

Current heritage tourism efforts in the plan area include the South Carolina National Heritage Corridor, a federally designated national heritage area extending from the Appalachian Mountains to the South Carolina coast through 17 counties. The heritage corridor promotes and interprets the State's history, with emphasis on colonial settlement, agriculture, African-American history, trade routes and the State's ports.

Another heritage tourism focus in the plan area is the Gullah/Geechee Cultural Heritage Corridor. It extends along the coast from North Carolina, to northern Florida and includes the Francis Marion National Forest. Its focus is on the recognition of the Gullah people and their culture.

13.1.1.5 Information Needs

The Francis Marion National Forest contains a rich prehistoric record beginning 10,000 years ago up to European contact in the sixteenth and seventeenth centuries. Several seminal archaeological investigations conducted on or near the Forest from the late 1970s through the early 1990s served well as the primary authorities on the cultural chronology and adaptations of prehistoric groups on the central South Carolina Coastal Plain. However, in the last 17 years the Forest has generated an enormous amount of data that has outstripped our ability to synthesize the new information into a coherent system of research priorities to guide the cultural resources compliance process. This assessment documents the information needed to update the heritage database and to provide the necessary foundation to achieve research efficiency within a larger framework of cultural contexts.

It will take several years to achieve the objectives identified here. The first objective is to update and more fully develop the cultural chronology. Since the 1980s, the Forest generated a significant body of new information, particularly ceramic types and absolute date associations, but very little of the new data is incorporated into ongoing cultural resource inventories because there is no single, updated synthetic source to consult. The second objective would be to construct a database of site component density, which can then be analyzed in the following year within GIS to develop geographic models of site location and subsistence-settlement by cultural phase. The results of this modeling will serve as the basis for generating a series of contexts within the broad span of the cultural sequence.

Issues identified in the updated culture chronology and settlement pattern analysis should be developed to create a series of historical contexts for each phase or period. The major themes of adaptation and cultural interaction should be assembled and a series of research issues should be generated to make possible a more informed evaluation of site significance under the National Historic Preservation Act and the National Register of Historic Places. This will lead to recommendations for the more efficient management of the prehistoric cultural resources on the Forest.

Heritage program plans, one of seven elements that define a heritage program managed to standards, defines the desired condition of the heritage program on the Forest and includes program objectives, guidelines, and standards that are part of broad-scale land use planning. A heritage program plan is a synthesis of cultural resource information and can address information needs including:

- Archaeological, historical, and ethnographic background
- Cultural resource distribution, density, and diversity
- Physical condition of cultural resources
- Existing and foreseeable threats to cultural resources
- Traditional values ascribed to cultural resources
- Historic contexts represented by the cultural resources on the Forest

A heritage program plan can provide information on the projected number of cultural resources, and the types and locations of cultural resources which can improve predictive modeling and site identification strategies.

14 Land Status and Ownership, Use and Access Patterns

14.1.1.1 Preliminary Findings

Land Status and Ownership. The Forest has identified current ownership as well as tracts with priorities to acquire and convey. The greatest potential is for collaboration to purchase or exchange tracts within the Forest. A total of 1,037 acres have been acquired since 1996 in cooperation with The Nature Conservancy, Charleston County Greenbelt Funds, and willing property owners within the Forest.

Land Use. The Forest currently manages 108 special uses issued for land use within the Forest boundary by adjacent landowners, utilities, and commercial/non-commercial entities (road uses and recreation events). The 1996 FEIS stated there were 137 special use permits. This number fluctuates due to the issuance, expiration and termination of various permits, the seasonal nature of temporary permits, and the consolidation of multiple permits to a single permit holder where appropriate. There is a very high potential for continued and increased requests which will be received on a case-by-case basis and managed through the special use permit process. There is also the potential for an increased number of encroachments and trespass on national forest lands where the use of the Forest by adjacent landowners and Forest users is recognized.

There is one major corridor bisecting the Forest that supports a Santee Cooper utility line. It is 29.12 miles long and varies in width between 100 and 200 feet. This corridor is also the location of a permitted Carolina Gas pipeline which is 21.4 miles long. This coincident use is an example of where a designated utility corridor can support multiple major uses and impact a defined acreage in the Forest to meet public demand. Other utilities such as telephone, fiber optic and cable permitted on the Forest are located coincident to each other and generally along road systems. There is no carrying capacity for recreation uses (trails, waterways, recreation sites).

Access Patterns. Access is identified on the Forest through roads and trail management systems as well as special uses issued for easements and commercial road use. Access includes permits, FLPMA and FRTA road easements, and utility rights-of-way. There is a potential for increased requests which will be managed on a case-by-case basis through the special use permit process.

14.1.1.2 Introduction

This assessment should identify and evaluate available information relevant to the plan area for land status and ownership, use, and access patterns (36 CFR 219.6(b)).

14.1.2 Land Status and Ownership

14.1.2.1 Existing Information

Land ownership is the basic pattern of public and private ownership within the proclamation boundary. Land ownership is defined as the condition of the title of land or interest in land under the jurisdiction of the Forest Service. The following conditions are also included under this definition: the manner in which these lands came into Federal ownership; encumbrances and restrictions which affect the administration of the land; interests owned by the government in private lands; and the interest in government lands held by others.

As established in 36 CFR 200.12, the Land Status Records System is the official repository for all realty records and land title documents for national forest system lands. The records system is maintained at the regional office level and is the electronic record for realty information backed up by hard copy records maintained at the region, administrative units, Federal Records Center, and National Archives Records Administration offices.

The Land Status Records System records include an accurate account of acreage, condition of title, administrative jurisdiction, rights held by the United States, administrative and legal use restrictions, encumbrances, and access rights on lands and interests in land in the national forest system.

Maintenance of the Land Status Records System includes the final review, processing, posting, and permanent retention of records reflecting any change in land ownership status. The compilation includes notation and filing of laws and Executive orders affecting land ownership and jurisdiction, all land ownership adjustments (exchange, purchase, donation, transfer, boundary modification, title claims, sales, grants and excess property), use restrictions (rights-of-way acquired or granted, reservations, outstanding rights, partial interests, easements), and changes attributable to resurveys. The records system and such title and realty records shall be made available for field personnel and the public.

The Land Areas of the National Forest System Report is an annual publication that tracks national forest system ownership and provides the latest statistics on the lands administered by the Forest Service. The report provides acreage figures for national forest system lands in a variety of ways such as by forest, state, county, congressional district, and for wilderness and other special designations (scenic areas, NRAs, experimental forests).

Land status can also include zoning for adjacent private lands. Zoning for private lands is usually provided under state, county, and municipal laws through comprehensive plans for local use and zoning.

Zoning on private lands within the plan area of the Francis Marion National Forest in Berkeley County is covered by Berkeley County South Carolina 2010 Comprehensive Plan and Berkeley County South Carolina Code of Ordinances. Zoning on private lands within the plan area of the Francis Marion National Forest in Charleston County is covered by Charleston County South Carolina Comprehensive Plan and Charleston County South Carolina Zoning and Land Development Regulations Ordinance.

The Forest supervisor's office created a Land Ownership Adjustment Strategy in 2005 that includes both the Francis Marion and Sumter National Forests. Prepared with interdisciplinary input from each district, the purpose of the strategy was to establish goals to create the optimum landownership pattern for each forest. The Land Ownership Adjustment Strategy prioritized areas within the Forest that would be desirable to acquire or convey using a high, medium, or low priority designation. An example is Fairlawn Plantation which remains the largest private inholding within the proclamation boundary of the Forest. The strategy serves as a guide to assist in prioritizing land adjustment activities.

Some of the goals contained on the Land Ownership Adjustment Strategy are to consolidate fragmented lands; dispose of isolated lands that have lost national forest character and have become difficult to manage; and encourage conservation organizations, state, and local governments and other large landowners to acquire conservation easements on no-Federal lands to limit development adjacent to the Forest (2008 Forest Plan Review).

14.1.2.2 Current Condition and Trends

The Francis Marion National Forest is comprised of approximately 259,537 acres (based on 2012 GIS, Basic Surface Area layer).

The Forest is experiencing the effects of urbanization at a higher level than other Forests in the Southern Region. Acquisition funds have been very limited while timber companies have been divesting themselves of large acreages near the Forest. Land acquisition has become increasingly difficult and private landowners are less willing to allow public access across their lands (2008 Forest Plan Review).

One of the greatest trends currently affecting the management of land ownership status and land use and access patterns is the escalating housing development on private rural lands adjacent to existing national forest. As more people choose to live at the urban fringe and in scenic, rural areas, open space lands such as farms, including those adjacent to national forest system, are being lost to development (Forest Service 2007). Development on adjacent properties has led to an increased number of issues with trespass, illegal trails, title claims, encroachments and law enforcement problems such as poaching, illegal posting of national forest lands, and user conflicts.

One special consideration for the acquisition of property adjacent to national forest lands is known as “heirs property,” where all family members own the land as “tenants in common” which gives each family member undivided rights. When a family member dies, the ownership passes down to living heirs who are determined by probate laws. When probate is not completed within the time required by the State, the property becomes “heirs property” and the court must determine how to divide the land among the heirs.

Traditionally, heirs property has been managed by “word of mouth” to verbally transfer interest to other family members. Quitclaim deeds have been used in an attempt to transfer interest between family members and are used when the title holder is deceased. Numerous legal and financial issues can impact the transfer of heirs property which can result in the loss of ownership. If any one of the heirs cannot pay the others for their interest in the land, the court can sell of the land often at reduced prices. This can create a situation where developers acquire these tracts for minimum prices and create islands of development within the proclamation boundary of the Forest (Gullah Geechie Corridor Management Plan 2012).

Due to increasing urbanization of towns such as Mt. Pleasant, the City of Charleston, and Moncks Corner, annexation and zoning have become an increasing concern to the Forest and the Forest’s ability to manage within an “urban interface.” These annexation proposals from local communities can create the potential for user conflicts on the Forest and could raise issues of Federal/state supremacy.

Even within national forest boundaries, the number of housing units on privately held lands increased from 0.5 to 1.5 million between 1950 and 2000 (Stein et al. 2007). It is estimated that between the years 2000 and 2030, a substantial increase in housing density will occur on more than 21.7 million acres of rural private land (8 percent of private land) located within 10 miles of national forest system lands (Stein et al. 2007). Residential development projections for private lands have increased over the past 20 years and are expected to continue to increase as more people wish to move to the coastal areas of South Carolina and more specifically outside the urbanized areas associated with cities such as Charleston and Mt. Pleasant.

Berkeley County has seen an increase in population of 83.2 percent for the period 1980 to 2009. This rise in population has led to increased need and requests for the National Forest to provide access and utilities to support the growth.

Berkeley County is the third largest land base in the State of South Carolina. Lands within the National Forest proclamation boundary include conservation/open lands, single family, and open areas. Tracts adjacent to National Forest include private, commercial, and many tracts considered "heirs property." The heir properties have been passed down generationally without clear title.

In Berkeley County, the majority of lands within the national forest system proclamation boundary are zoned "constrained residential." The emphasis is towards agricultural uses and this zoning considers the introduction of municipal water and opportunity for community septic systems in lieu of sewer systems. Also, along the edges of the proclamation boundary, there are communities zoned "low density suburban," where as many as four units per acre are allowed and the introduction of water and sewer may occur to support development (Berkeley County Comprehensive Plan).

Charleston County had a population of 309,969 in 2000 with a projected increase of 15 percent to 357,127 in 2010.

Charleston County as a whole has lands designated as approximately 14 percent "open space", 4 percent "wetlands" and 12 percent "agriculture.' Most specifically, lands adjacent to the National Forest are primarily considered agricultural and wetlands. There are two rural municipalities, Awendaw and McClellanville, within the National Forest boundary and located along the U.S. Highway 17 corridor. This corridor is recognized as a special planning area (Charleston County Comprehensive Plan).

Partners: Several local and community groups have been active in support of the activities of the Francis Marion National Forest. They include the Sewee Association, a friends group for both the Forest and Cape Romain NWR, the Sewee to Santee Task Force, and the Sewee Summit, whose mission is "Working together to ensure the future of the Francis Marion National Forest, the Cape Romain National Wildlife Refuge, and the culture and quality of life of the people who live there." Most recently, the Sewee Summit formed the "Bulls Bay Historic Passage Chamber of Commerce," to promote a vision of "A healthy rural community deeply rooted in its long history, in harmony with and enriched by the extraordinary natural resources that surround it." The Nature Conservancy is a long-standing partner working with the Forest not only for land acquisition, but habitat improvement to include prescribed fire management and restoration of the Longleaf Pine Wiregrass Ecosystem.

With the increase of development on adjacent private lands and inholdings, forests face management challenges associated with the control of property lines. Limited funding, resources, and workforce have not kept pace with the increased development on adjacent private lands. It is estimated that control of property boundary lines for public land has been heavily compromised because of infrequency and reduced scheduled maintenance, as well as encroachment and trespass by adjoining landowners.

14.1.2.3 Information Needs

An accurate GIS boundary layer is needed and is valuable to track the miles of property boundary for monitoring and maintenance. This tool is also valuable for tracking

encroachments/trespasses as identified. The Francis Marion currently has an Automated Lands Project layer maintained by the Status Department of the Region 8 lands staff.

14.1.3 Land Use

14.1.3.1 Existing Information

Land use is administered by special use authorizations, which include permits, leases, and easements that allow occupancy, use, rights or privileges on national forest system lands. Special use authorizations are legal instruments whose terms and conditions are fully enforceable when reasonable and consistent with law, regulation, and policy. The mission of the special uses program is to manage the use and occupancy of national forest system land in a manner that protects natural resource values, promotes health and safety, and is consistent with Forest land and resource management plans.

Currently, the Forest Service uses the Special Uses Data System to create and administer special use authorizations. The data system is supported by hard copy files at district, Forest, and in some cases, regional offices. A component of the Special Uses Data System is special use permit billing and it is the system of record for documenting compliance, insurance, inspections and reporting. The information available from the system can be somewhat undependable depending on the quality of the data input.

In April 2004, the U.S. Department of Commerce published, Improving Rights of Way Management Across Federal Lands: A Roadmap for Greater Broadband Deployment. The intent of the report was to identify and recommend changes in Federal policies, regulations, and practices to improve the process of granting rights-of-way for broadband communication networks on lands under Federal jurisdiction.

In June 2011, the Office of Inspector General (OIG) completed an audit report, Forest Service Administration of Special Use Program. The OIG initiated the audit to assess the effectiveness of the special use program and to determine if Forest Service efforts are meeting program objectives. Access is defined as the legal rights-of-way acquired by the Forest Service across non-national forest system land for the management and use of national forest system land. (Access granted by the Forest Service to others across national forest system land is covered in section 14.1.3 “Land Use”).

As established in 36 CFR 200.12, the Land Status Records System is the official repository for all realty records and land title documents for national forest system lands, including acquired rights-of-ways (see full discussion of Land Status Records System in section 14.1.2 “Land Status and Ownership”).

In April 1992, the General Accounting Office (GAO) completed a report, Federal Lands Reasons for and Effects of Inadequate Public Access. The report responded to a congressional request for the GAO to complete a review of the adequacy of public access to land managed by the Forest Service and the BLM.

14.1.3.2 Current Conditions and Trends

Development of residential areas adjacent to the Forest has increased the demand for utility services prompting an increase in special use permits. The demand for special use authorizations is higher where public and private boundaries meet. Private landowners often require an authorization from the Forest Service for private road access, waterlines, and other utilities. The

need to grant additional authorizations increases as private lands adjacent to or within the national forest system boundary are subdivided. This increases the workload of the special uses program. At present, the Forest Service lacks the resources it needs to manage the special uses program (OIG 2011). An increase in special uses also influences the management of the plan area because authorizations become an encumbrance on the land that may limit resource management decisions.

An additional driver of change in land uses is the ever growing demand of technology in the field of communications. The request for communications sites on national forest system lands has increased as these services expand to remote locations. Communication sites are critical for the wireless industry, which has a growing need for additional antenna sites as well as fiber optic cable corridors. This includes remote communities once considered too isolated for the investment of infrastructure capitol (Federal Rights-of-Way Working Group 2004). There is also a need to improve and create more reliable sources of electricity to locations within the Forest boundary which can lead to more acreage encumbered by utility rights of way within the Forest.

Special use permit requests fluctuate. Requests for easements and right-of-way permits seem to be dictated by the economy or the need to divide family property among heirs. Most recently, the requests for easements has been consistent and steady with landowners needing to legitimize or legalize access in order to sell property or obtain loans.

There has been increased interest in special use permits for recreation events and activities. As more of the population looks to find nature based experiences, they are gravitating to organized events such as adventure races, foot races, and outfitter guided experiences. It is expected for this trend to continue in the foreseeable future.

There are occasional requests for research permits and mitigation bank projects on the Forest.

Utility requests have increased in recent years to facilitate the need to provide electricity, telephone, fiber optic, water and amenities to private landowners within the Forest boundary. The Forest is currently working with Central Electric Cooperative, Inc., and the USDA Rural Utility Services to evaluate a route (including national forest system lands) to provide more reliable electricity to the McClellanville area.

14.1.3.3 Information Needs

In 1999, the Forest Service issued guidance encouraging the Forests to consider including appropriate programmatic actions and decisions within forest's plan revisions that will improve efficiencies in project-level special use procedures and customer service. This direction was reiterated after the 2011 OIG audit of the Forest Service special use program in a Washington Office memo dated September 19, 2011 (Holtrop Memorandum 2011). Forest planning decisions that could improve special uses management efficiencies include land allocations for long-term use or occupancy, such as communication site designations. Other planning decisions to consider include establishing management standards and guidelines within each land allocation and Forestwide or areawide standards and guidelines for special uses.

For planning purposes, it is necessary to evaluate current and potential communication sites on all forests to determine if they should be designated for plan revision. Designating communication sites in forest plan revision is desirable to help guide decisions related to the expansion of existing permitted sites and the authorization of new sites. As technology in the communications industry continues to expand, there will be additional demands on the Forest Service to accommodate these uses.

Development of a GIS layer that shows the location of all special use authorizations would also be useful. This layer would highlight the relationship of permitted uses to landownership patterns. GIS layers are not necessarily required to develop the Forest plan, but would be a valuable tool for drawing conclusions related to land uses in the Forest plan and determining if standards and guides would be helpful in specific areas.

14.1.4 Access Patterns

14.1.4.1 Existing Information

Increased housing density in areas adjoining national forest system lands can increase the potential for encroachment, trespass, and unauthorized use and occupation of the public's land and resources (Stein et al. 2007). Encroachments onto national forest system lands can transform publicly owned land into privately claimed land for uses such as pastures, garbage dumps, lawns, garden spots, personal storage sites and in some cases, garages or portions of homes and garages. Another significant impact from development on adjoining private lands includes illegal private road building and user-created off-highway trails on national forest system lands. Illegal horse, biking, and hiking trails also originate from adjacent developed private lands.

The Francis Marion National Forest is comprised of approximately 259,537 acres. The planning areas consist primarily of a large percentage of national forest lands with several local communities and private ownerships dispersed throughout the boundary. The current acreage compares with 249,500 acres of national forest system lands recorded in 1996 (FEIS).

The Forest is bounded to the north by the Santee River, to the east by, Cape Romain National Wildlife Refuge, Bulls Bay and the Atlantic Ocean, to the south by the Wando River, and to west by lands adjacent to the Cooper River, Moncks Corner, Lake Moultrie and St. Stephen. The Forest boundary includes 588 miles of property boundary currently managed by the Forest.

Based on a recent 6-year average, an average of 4.66 miles of boundary lines have been maintained annually and 1.38 miles of boundary have been surveyed annually.

The majority of private lands adjacent to the National Forest are owned by private individuals. The large blocks of timber company lands formerly found within the boundary and adjacent to national forest system lands have been sold to private or corporate ownership within the past 10 years. The Forest does share its eastern boundary with the U.S. Fish and Wildlife Service, Cape Romain National Wildlife Refuge. This joint boundary is unique along the Atlantic Coast, and presents opportunities for increased natural resource management objectives.

Most of the land comprising the Francis Marion National Forest was acquired through individual purchases from timber companies and willing sellers beginning in the 1930s. Condemnation was used predominantly as a means to clear poor title on much of the privately held lands. There are occasional requests to "give back" or deed back lands to heirs of former landowners where they feel the government acquired a cemetery or home place without legal authority.

Land ownership status can change over time through land adjustments. Land adjustments involve transfer of fee title, resulting in a change in legal ownership. Land adjustments can result from land exchange, purchase, donation, sale, transfer condemnation and interchange. In recent years, the Forest has used its Land Ownership Adjustment Strategy to consolidate ownership, reduce miles of landline maintenance, and more effectively manage its resources.

Ownership of national forest system lands within the Francis Marion planning area has changes since the last planning cycle. Since 1995 there has been a net increase in national forest system ownership of 1,037 acres. The gain in National Forest acreage can be attributed to the purchase, exchange, and donation of acres within the Forest boundary. Funding from the Land and Water Conservation Fund and partners such as The Nature Conservancy and Charleston County Greenbelt have made these acquisitions possible.

The Forest Service's special use program authorizes the use and occupancy of national forest system lands that provide a benefit to the general public and protect public and natural resource values. Currently, there are over 74,000 authorizations on national forest system lands for over 181 types of uses (OIG 2011). Uses in the lands program include utility transmission lines, telecommunications, research, military training activities, and granting public and private road rights-of-way.

At the time of this assessment, there were 108 special use authorizations issued within the planning area. This does not include 8 to 12 temporary recreation special use permits and 5 to 10 temporary non-commercial group use and research special use permits annually.

Table 14-1. Special use authorizations

Type of Use	Number of Authorizations
Research	1
Playground	2
Research, cultural resources	1
Churches/cemeteries	10
Group use	5–10 average
DOT/FRTA/FLPMA easements	51
Outfitter guide	3
Recreation events	8–12 average
Telecommunications/fiber optic	7
Parking/Playground	2
Fence	2
Railroad	1
Water quality monitoring	1
Museum/visitor center	1
Mineral	2
Oil and gas	1
Sewage/water transmission	17
Signs	2

Note: Numbers can fluctuate regularly with the issuance of new permits, renewals, closures, and terminations.

The majority of existing special use permits is for transportation-related uses. There are 52 transportation permits and easements as follows: 3 Department of Transportation Easements, 1 Railroad right of way, 6 Federal Roads and Trail Act (FRTA) easements, 24 Federal Land Policy and Management Act (FLPMA) easements, and 18 FLPMA permits, In addition, there are 42 FLPMA permits and FLPMA easements issued to private landowners for access to adjacent lands. As requested, Temporary Road Use Permits are issued for commercial haul on national forest system roads. Other permits are issued as follows: 5 recreation permits (including outfitter

guides); 8 to 12 recreation events and 5 to 10 annual group use permits; 1 research permit; 10 churches/cemeteries; and 7 telecommunication permits.

During the process of developing the National Forest road and trail system across the country, the Forest Service acquired approximately 30,000 rights-of-ways across other ownerships. There are 20 acquired rights-of-ways on the Francis Marion and several temporary rights-of-ways secured for intermittent access needs. It is the goal of the Forest to attempt to secure all future rights-of-ways as permanent through fee or reciprocal rights-of-way easements.

Currently, the Forest has 575.6 miles of system roads and 177 miles of system trails throughout the Forest.

There are increasing demands on the use of Forest System roads by local residents to ingress and egress homes and subdivisions as well as by busses and trucks serving local schools and businesses. Of the 575.6 miles of system roads on the Francis Marion National Forest, 24.5 miles are maintained cooperatively by Berkeley County (Cooperative Road Use Agreement dated September 26, 1977) and 17.4 maintained by Charleston County (Cooperative Road Use Agreement dated March 27, 1985).

It is assumed that the Forest has acquired legal access from private landowners in the majority of the main access roads/entry points to national forest system lands currently being used for public access and management of national forest system lands. To determine if this is the case, an in-depth access analysis would need to be completed, which would require substantial time and funding for a qualified lands specialist to complete.

There are known access points to the Forest (both trail and road) where permanent legal access for improved recreational and administrative access would be valuable. Complex right-of-way acquisition procedures create obstacles to completing access needs within established project timeframes.

14.1.4.2 Current Condition and Trends

In 1991, the Forest Service issued guidance to field offices to improve access planning efforts. The guidance required each forest plan to include a transportation plan that would identify the access rights needed to support the resource objectives of the respective forest plan (GAO 1992).

To accomplish the goals set out in this guidance, it is necessary to develop an inventory of roads and trails that provide access to the Forest and evaluate if the Forest has legal and physical access on them. A component of the inventory is to verify legal access and physical access is currently being held. The inventory should review access and perfect title where needed on existing roads and trails to ensure access is not lost in the future. In addition, the inventory should identify areas where legal and physical access would ensure public access as well as the ability to manage national forest system lands in the future. The Francis Marion National Forest began an inventory, but due to the lack of funds the inventory has not been completed.

Additional road mileage gained through ongoing land acquisitions has increased the deferred maintenance backlog. Most, if not all, of these new roads have been placed into closed, maintenance level 1 roads.

Continual reduction in funding has resulted in choices on the level and degree of maintenance needed throughout the Forest road system. Such choices included whether to decommission or close a road, conduct spot surfacing, provide maintenance to surface drainage, culvert

placement/replacement, bridges and aggregate surfacing. Roadside mowing and trimming heavy vegetation and other measures are still necessary for safety but limited funding is not meeting the need.

The Forest is currently reviewing all existing system roads in its transportation analysis process.

Private landowners' unwillingness to grant unrestricted public access across their land has increased as the public's use of Federal land has increased (GAO 1992). Factors contributing to inadequate access were private landowners' concerns about vandalism, potential liability, and desire for privacy or exclusive personal use (GAO 1992).

Though the GAO report is somewhat dated, private landowners cite the same reasons today for their unwillingness to grant permanent public access across their land. Combine this with the trend of development of subdivision of lands adjacent to the Forest, acquiring legal access becomes much more costly and difficult.

Where former access across national forest system lands was never perfected, it is becoming increasingly difficult to work with private landowners to gain permanent legal access. This limits management options as well as the public's opportunities to access national forest system lands.

14.1.4.3 Information Needs

Prescribed fire management on national forest system lands adjacent to residential or commercial centers needs additional review. Where there is a heavy urban interface with national forest system lands, the ability to use prescribed fire as a tool for understory management is almost non-existent. The Forest needs to continue to evaluate cooperative means to use prescribed fire or other understory reduction tools to manage these areas.

15 Designated Areas

This chapter assesses current conditions and trends for designated areas on the Francis Marion National Forest, including wilderness, wild and scenic rivers, research natural areas, inventoried roadless areas, botanical areas and others. Some categories of designated areas may be designated only by statute and some categories may be established administratively in the land management planning process or by other administrative processes of the Federal executive branch. For this assessment, there are three categories of designated area, by statutorily designated, administratively designated, or by regional forester. This chapter shall identify and evaluate available information relevant to the plan area for existing designated areas located in the plan area including wilderness and wild and scenic rivers and potential need and opportunity for additional designated area (36 CFR 219.6(b)). The assessment does not require an inventory and evaluation of individual land areas within the plan area for potential designation.

15.1 Statutorily Designated Areas

The Francis Marion National Forest has four statutorily designated wildernesses established by Congress in 1980 (Public Law 96-560 od 1980). More additional information about these wilderness areas and other information can be found at [www.wilderness.net]. The Francis Marion does not have any of the following statutorily designated areas located on the Forest: national heritage area, national monument, national recreation area, national scenic area, national trails, national scenic trails, national historic trails, designated wild and scenic rivers, or highway systems, interstate and national.

15.1.1 Wilderness

15.1.1.1 Preliminary Findings

►Since the 1996 Forest plan was written, an information needs assessment was completed. In 2011, several concerns were raised about effects to wilderness character from a variety of sources include recreation use impacts, historical exclusion of fires, effects of nonnative invasive species plants and animals, effects of air pollution, aquatic habitat degradation, unmanaged illegal use and effects of climate change.

►The 1996 Forest plan contains direction on management of wilderness areas in management area 2 in chapter 4. This Forest plan direction protects the wilderness character of the four designated wilderness areas.

►NVUM (National Visitor Use Monitoring, FMS, 2008), found that over 11,000 people visit the wilderness on both the Francis Marion and Sumter National Forests. The monitoring does not provide the use on each wilderness individually, so it is not possible to assess what percent of that use is on wilderness on the Francis Marion. However, managers can determine that of the four wildernesses on the Francis Marion, Wambaw Creek receives the majority of the use.

15.1.1.2 Introduction

In 1964, Congress established the National Wilderness Preservation System. This legislation was enacted to permanently protect some of the most undisturbed Federal natural lands in the United States. At its birth, the National Wilderness Preservation System included just 54 areas and a little over 9.1 million acres. The Congress has since added hundreds more areas and millions more acres, increasing the system to 702 areas and over 107 million acres. For the most part

these are the wildest of Federal lands in the Nation [Wilderness.net at http://www.wilderness.net/index.cfm].

The Wilderness Act of 1964, as enacted September 3, 1964, and amended October 21, 1978 (16 U.S.C. 1131-1136), specifies congressional policy to secure for the American people an enduring resource of wilderness for the enjoyment of present and future generations. It defines wildernesses as areas untrammeled by people that offer outstanding opportunities for solitude and directs agencies to manage wilderness to preserve natural ecological conditions (section 2320.6). With certain exceptions, the Act prohibits motorized equipment, structures, installations, roads, commercial enterprises, aircraft landings, and mechanical transport. The Act permits mining on valid claims, access to private lands, fire control, insect and disease control, grazing, water resource structures (upon the approval of the President), and visitor use.

The Wilderness Act states in Section 2(a),

> In order to assure that an increasing population, accompanied by expanding settlement and growing mechanization, does not occupy and modify all areas within the United States and its possessions, leaving no lands designated for preservation and protection in their natural condition, it is hereby declared to be the policy of the Congress to secure for the American people of present and future generations the benefits of an enduring resource of wilderness. For this purpose there is hereby established a National Wilderness Preservation System to be composed of federally owned areas designated by Congress as "wilderness areas", and these shall be administered for the use and enjoyment of the American people in such manner as will leave them unimpaired for future use and enjoyment as wilderness, and so as to provide for the protection of these areas, the preservation of their wilderness character, and for the gathering and dissemination of information regarding their use and enjoyment as wilderness; and no Federal lands shall be designated as "wilderness areas" except as provided for in this Act or by a subsequent Act.

Wilderness is defined in the act as,

> …in contrast with those areas where man and his own works dominate the landscape, is hereby recognized as an area where the earth and its community of life are untrammeled by man, where man himself is a visitor who does not remain. An area of wilderness is further defined to mean in this Act an area of undeveloped Federal land retaining its primeval character and influence, without permanent improvements or human habitation, which is protected and managed so as to preserve its natural conditions and which (1) generally appears to have been affected primarily by the forces of nature, with the imprint of man's work substantially unnoticeable; (2) has outstanding opportunities for solitude or a primitive and unconfined type of recreation; (3) has at least five thousand acres of land or is of sufficient size as to make practicable its preservation and use in an unimpaired condition; and (4) may also contain ecological, geological, or other features of scientific, educational, scenic, or historical value.

Also the act defines the parameters of management by stating “Except as otherwise provided in this Act, each agency administering any area designated as wilderness shall be responsible for preserving the wilderness character of the area and shall so administer such area for such other purposes for which it may have been established as also to preserve its wilderness character.”

The Wilderness Act of 1964 does not define wilderness character and there is no discussion about its meaning in the legislative history of this act (Scott 2002). The Forest Service national framework for monitoring wilderness character (Landres et al. 2005) concluded that wilderness character is ideally described as the unique combination of (a) natural environments that are

relatively free from modern human manipulation and impacts; (b) opportunities for personal experiences in environments that are relatively free from the encumbrances and signs of modern society; and (c) symbolic meanings of humility, restraint, and interdependence in how individuals and society view their relationship to nature. The framework uses the definition of wilderness from Section 2(c) of the 1964 Wilderness Act to identify four qualities of wilderness related to wilderness character.

- *Untrammeled* – wilderness is essentially unhindered and free from modern human control or manipulation.
- *Natural* – wilderness ecological systems are substantially free from the effects of modern civilization.
- *Undeveloped* – wilderness is essentially without permanent improvements or modern human occupation.
- *Outstanding opportunities for solitude or a primitive and unconfined type of recreation* – wilderness provides outstanding opportunities for people to experience solitude or primitive and unconfined recreation, including the values of inspiration and physical and mental challenge.

Demands, Values and Attitudes

The Forest Service research group located in Athens, Georgia, has been collecting data and producing reports about the attitudes and values of Americans since the 1980s. A primary part of this data collection effort has been the National Survey on Recreation and the Environment. The survey includes attitudes and values of designated wilderness. The most recent rounds (versions) of the survey were conducted between late fall of 2006 and October 2007. Included in these rounds were questions about what Americans see as the values derived from protection of Federal wildlands as wilderness (Cordell et al. 2008). One of the primary sets of questions included in recent rounds of the National Survey on Recreation and the Environment asked respondents (16 years of age or older) about their attitudes toward the National Wilderness Preservation System. Basically the survey asked respondents what they see that is of value in protection of some of the Federal wildlands as wilderness. Thus, “values”, as used here, refers to those aspects or benefits of wilderness people perceive as important.

Two values stand out as highly important reasons to Americans for having Federal wilderness. Over 90 percent of Americans said protection of air and water quality is very to extremely important values of wilderness. Four additional values also stood out, although they seem to be a little less important. Included are protection of wildlife habitat, knowledge that future generations will have wilderness to visit (bequest value), protection of rare and endangered plant and animal species, and preservation of unique wild plants and animals.

Overall, there were no differences by place of residence. Rural residents listed the 13 wilderness values in much the same order and level of importance as urban residents. Rural residents may have placed a slightly higher value on the tourism benefits of wilderness, though the difference was not statistically significant. There were only a few differences between people living in the four macro regions of the U.S. Somewhat fewer in the West region placed high importance on water quality and more people in the South put high importance on scenic beauty and spiritual inspiration. The West ascribed the greatest benefit to the option value of wilderness.

Over half of Americans continued to say there are not enough wildernesses, and 35 percent indicated the amount is about right in 2006 and 2007, up about 5 percentage points from 1999

and 2000. Over two-thirds favored designating more Federal lands as wilderness in their home state in 2006 and 2007, roughly the same percentage as 7 years earlier.

Current Designated Wilderness on Francis Marion National Forest

The wildernesses on the Francis Marion offer unique experiences, mostly swamps and tidal influenced streams in a primitive setting. All the areas provide many recreation opportunities such as nature study, birding, kayaking, hunting and fishing. There are 11 miles of water trail on the Wambaw Creek Wilderness. Hellhole Bay has 1.5 miles of non-motorized canoe trail.

Hellhole Bay (2,125 acres). In Hellhole Bay, from June through August (the wettest season), much of the ground is usually submerged under 2 to 18 inches of standing water. Insects abound, with mosquitoes, chiggers, and ticks reaching peak numbers from summer through fall. Many snakes, including poisonous water moccasins, copperheads, and rattlesnakes, make their homes here. Within most of the areas visibility is poor due to dense vegetation, and getting lost is easy. Hell Hole Bay takes its name from a large opening in the forest probably formed by wildfires dating back to before the 1700s. For much of the year the Hell Hole Canoe Trail (6- to 12-inches deep, 6- to 8-feet wide, and just over a mile long) crosses the bay, but during the dry season it becomes a mushy hiking trail. The trail passes bald cypress, tupelo, and spreading maple. There are no other trails in the area.

Wambaw Swamp (4,815 acres). Wambaw Swamp offers no trails and little dry ground. There is river-bottom hardwood swamp edged with small stands of pine. Wild orchids, lizard's tail, pickerel weed, sedges, and ferns dominate the understory. The water level is generally too low for canoeing. Insects, snakes, muck, and lack of dry campsites keep most people away. This may be the least visited spot in South Carolina.

Wambaw Creek Wilderness

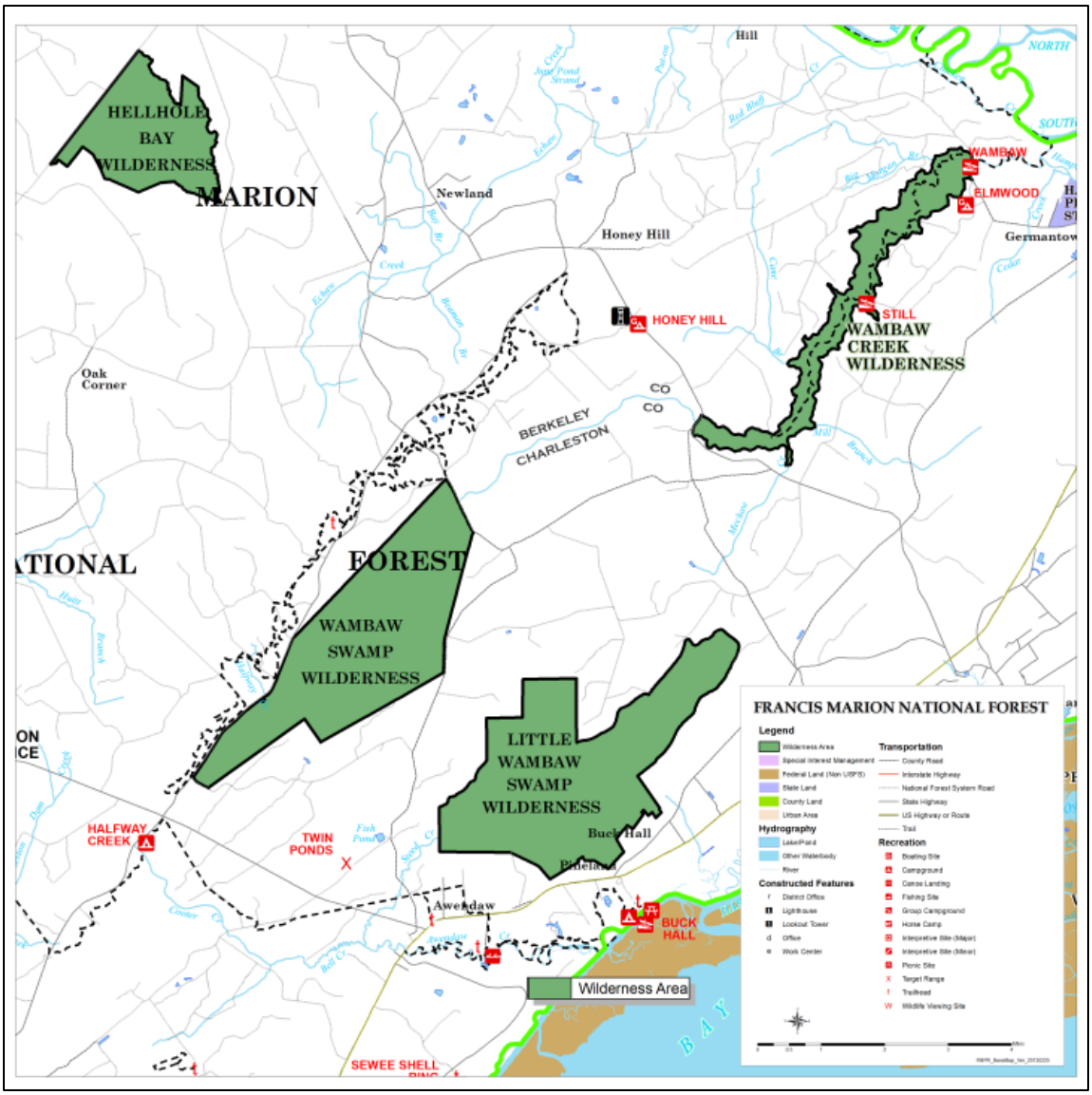


Figure 15-1. Wilderness areas on the Francis Marion National Forest

Little Wambaw Swamp (5,047 acres). Little Wambaw Swamp is a river-bottom land of hardwoods and sloughs. Bald cypress and tupelo grow impressively large, and about 60 acres of Forest in the southwestern portion of the swamp are believed to be untouched by logging. The dense understory consists primarily of wild orchids, bladderwort, and pickerel weed. Old, earthen railroad trams cross the area and provide high ground for foot traffic and possible spots to camp. Bridges where the trams spanned the many sluggish waterways are long gone, so wading is the norm.

Wambaw Creek (1,825 acres). In Wambaw Creek old dikes and canals bear evidence of attempts made by early European settlers to tame this region for agriculture. Giant cypress and gum trees line the creek, which flows down the heart of this long, slender Wilderness. The creek varies in width from 20 to 80 feet and provides a home for a few alligators. There are no hiking trails; to see Wambaw Creek the visitor will need a canoe and tide table. Proximity to the

Atlantic Ocean causes the creek to be greatly altered by tides. During low tide, the upper creek, especially the first 2 miles, can be blocked by logs.

Visitation. NVUM (National Visitor Use Monitoring, FMS, 2008), found that over 11,000 people visit the wilderness on both the Francis Marion and Sumter. But due to the inaccessibility of the wildernesses, it is difficult to assess what percent of that use is on wilderness on the Francis Marion. Of the four wildernesses however, Wambaw Creek does get the majority of the use. Visitors have opportunity to hire a guide for commercial support services during their visit into the wilderness. This commercial use is authorized in wilderness through special use permits issued to the commercial service provider by the Forest. There is an outfitter guide that uses Wambaw Creek. According to special use records, use continues to increase for special use trips and that may also indicate use is up on self-guided trips (Figure 15-2). Additional information is needed to assess the amount of use.

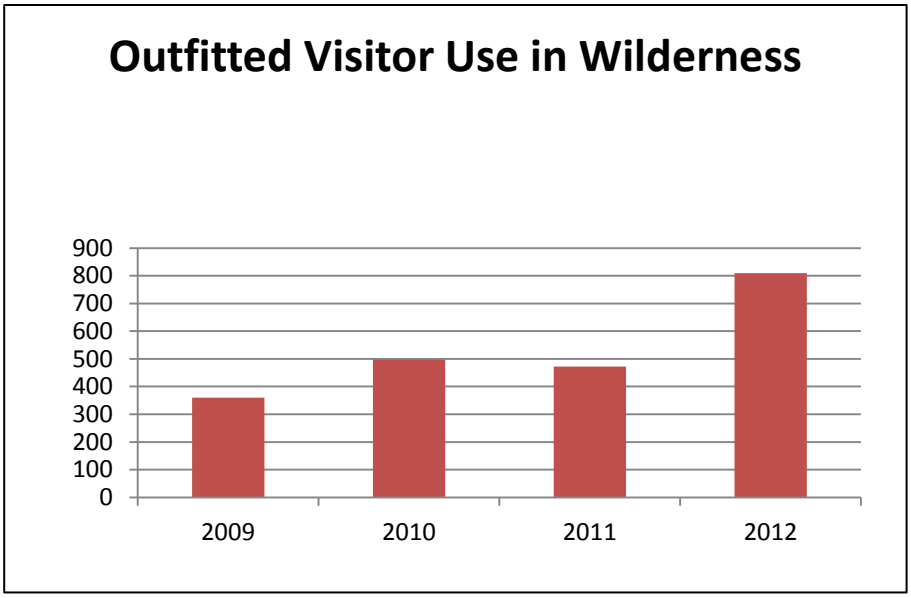


Figure 15-2. Outfitted visitor use in wilderness

15.1.1.3 Broader Landscape

The wildernesses (13,812 acres total) on the Francis Marion complement the 29,000-acre Cape Romain Wilderness managed by the U.S. Fish and Wildlife Service which runs for 22 miles along the Atlantic Coast. The wilderness lies east of the Intracoastal Waterway. The Cape Romain Wildlife Refuge (which is mostly wilderness) is bordered by Capers Island to the south and Murphy Island to the north; both S.C. Department of Natural Resources-protected lands. To the west of the Intracoastal Waterway lies the Francis Marion National Forest.

15.1.1.4 Current Management

Overall management for wilderness is guided by the 1964 Wilderness Act. Additional direction for management for all wilderness area on the Forest is contained in Forest Service Manual 2320, the Francis Marion National Forest Revised Land and Resource Management Plan (USDA Forest Service 1996).

The wilderness areas direction is within management area 2 and the goal of that area states "Preserve examples of large, relatively undisturbed hardwood small ecosystems and preserve

opportunities for a wilderness experience." The Forestwide desired future condition says wildernesses will "continue to be managed under the provisions of the Wilderness Act. The wilderness qualities have been enhanced by a management area which links the wildernesses areas together. The area of linkage is characterized by a general semi-primitive experience. Periodic fire occurs in the better drained uplands of these areas".

Detailed direction for managing the wilderness areas is currently provided by management direction through objectives, standards for management area 2 in the Forest plan (see Forest plan, page 4.4-5). One standard of management area 2 states "solitude of the area will be maintained by providing only minimal visitor facilities encourage users to disperse".

Wilderness visitor permits are one of the primary means for exercising management control from outside the wilderness boundary. There are no day-use permits required currently. Maximum group size for general public use and allocations for commercial use is another key management tool to govern visitor use numbers and facilitate limits on the frequency of user interactions from outside the wilderness boundary. There is currently no maximum group size limit for any of the wildernesses.

15.1.1.5 Risks/Uncertainties/Trends

In 2011 the Francis Marion National Forest conducted an information needs assessment for the wilderness on the Forest. The needs assessment identified, through an interdisciplinary approach, threats to wilderness character. Several items were identified including:

- There is concern about recreation use impacts in Wambaw Creek on the untrammeled wilderness, natural qualities, undeveloped wilderness and opportunities for solitude.
- There is concern about the historical exclusion of fire from wilderness affecting the natural qualities of vegetation and wildlife in Hell Hole Bay, Little Wambaw Swamp, and Wambaw Swamp. Also, there is a concern specifically is for the loss of open savannah in Hell Hole Bay, longleaf pine communities in Wambaw Swamp and possible need for some Forest buffer (fuel break) between Little Wambaw Swamp and adjacent private land.
- There is concern for effects of nonnative invasive plants on natural qualities of native vegetation and wildlife in all wildernesses. Some inventory monitoring is done adjacent to the wilderness. Several invasive species (Japanese climbing fern) are known to occur or are threatening to enter.
- There is a concern is for effects of feral hogs on the natural qualities of aquatic systems, soils, vegetation, and wildlife in all wildernesses. Also, there is a concern is also for nonnative invasive species such as apple snail, snakehead fish, and several other aquatic plant species.
- There is a concern is for effects of air pollutants on natural qualities of aquatic systems in all wildernesses.
- There is a concern for aquatic systems in Wambaw Creek from sedimentation and pollution from upstream adjacent private lands and due to salinity increase from Santee River diversions. Also, there is a concern for pollution runoff from Highway 17 corridor including private residences adjacent to Little Wambaw Swamp, hydrologic impacts of Hell Hole Road on Hell Hole Bay Wilderness, and hydrologic impacts of old rice field structures in LWS and WS.

- There is a concern about unmanaged illegal use for untrammeled quality in Little Wambaw Swamp and Wambaw Swamp due to illegal ATV use close to Wambaw Cycle Trail and trash dumping along Little Wambaw Swamp from adjacent private lands.
- There is a concern about effects of human induced climate change (caused by increase in greenhouse gases-carbon dioxide, methane, etc.) on streams, affecting natural qualities of air and aquatic systems.

Potential Wilderness

As a future step in the planning process the Francis Marion National Forest will address the potential need and opportunity for additional designated areas, such as potential wilderness areas. Direction in revised rules states that "Before the responsible official invites comments on the proposed plan, an inventory and evaluation is required for wilderness (see FSH 1909.12, Ch. 70), and an inventory of the eligibility of rivers for inclusion in the Wild, and Scenic Rivers System is required (see FSH 1909.12, Ch. 80); but these inventories are not required during the assessment (36 CFR 219.7(c)(v) and (vi))".

15.2 Administratively Designated

15.2.1.1 Preliminary Findings

►The Forest has several administratively designated areas including Little Wambaw Swamp and Hellhole Bay inventoried roadless areas, the Swamp Fox National Recreation Trail, Santee Experimental Forest and Guillard Lake Research Natural Area.

►The Francis Marion does not have any of the following administratively designated areas located on the Forest: national natural landmark, national historic landmark, national monument, scenic byway (Forest Service), scenic byway (national), or significant caves.

►**Roadless Areas.** Roadless areas are adjacent to wilderness and provide for isolation, solitude, and more primitive experiences. Two inventoried roadless areas are identified on the Francis Marion National Forest. Direction in the 1996 Francis Marion Forest Plan provides management of these two roadless areas in management area 29. Since the 1996 Forest plan was written, the Roadless Area Conservation Rule was released. Under the guidance in this rule, the two inventoried roadless areas were re-evaluated. Additional information may be needed to evaluate these two inventoried roadless areas as part of the Francis Marion Forest plan revision.

►**Swamp Fox National Recreation Trail.** The Swamp Fox Trail meanders through multiple management areas including 26, 27, and 28. There is no specific direction in any of those management areas related to national recreation trail. The 1996 Francis Marion Revised Land and Resource Management Plan does have specific visual quality objectives for the trail corridor.

►**Santee Experimental Forest.** The Santee Experimental Forest was designated for research by the Chief of the Forest Service in July of 1937. The experimental forest is located in Berkeley County, South Carolina, and is comprised of 6,053 acres within the Francis Marion National Forest. The Santee Experimental Forest research operations are guided by the Southeastern Forest Experiment Station. Research is centered on the ecology and management of forested wetland ecosystems in the South Atlantic Coastal Plain. The 1996 Forest plan allocates this area to management area 4 which provides management direction in terms of goals, desired future conditions, objectives, standards and guidelines.

►**Guilliard Lake Research Natural Area.** Guilliard Lake Research Natural Area is an area of remnant old growth located in bottomland along the Santee River. This research natural area should continue to serve as a baseline area for the research of cypress-tupelo forest type. Opportunities exist for occasional proposals for research or monitoring to be conducted by academic institutions. As relevant, special use permits may be issued and results shared with the National Forest at termination of data collection. The 1996 Forest plan allocates this area to management area 4.

15.2.2 Introduction

The Forest has several administratively designated areas including Little Wambaw Swamp and Hellhole Bay inventoried roadless areas, the Swamp Fox National Recreation Trail, Santee Experimental Forest, and Guillard Lake Research Natural Area. The Francis Marion does not have any of the following administratively designated areas located on the Forest: national natural landmark, national historic landmark, national monument, scenic byway (Forest Service), scenic byway (national), or significant caves.

15.2.3 Inventoried Roadless Areas

15.2.3.1 Current Conditions

Inventoried roadless areas are designated areas under the Roadless Area Conservation Rule (RACR; USDA Forest Service 2001; 36 CFR Part 294). These areas were first inventoried by the Forest Service in 1972, as part of the Roadless Area Review and Evaluation phase I (RARE I). A second inventory was completed for RARE II in 1977 and then in the RACR in 2001.

The Francis Marion National Forest has two inventoried roadless areas on the Forest, Hellhole Bay Extension (890 acres) and Little Wambaw Swamp Extension (530 acres) that were identified in the 1996 plan and then again in the 2001 RACR. A general evaluation of ecological conditions on the Forest can be found in section 2 “Assessing the Ecological Sustainability and Diversity of Plant and Animal Communities.” Additional information about roadless area character may be needed in support of the evaluation of need and opportunity for additional wilderness on the Forest.

15.2.3.2 Broader Landscape

There are no other inventoried roadless areas in the immediate area of the Francis Marion, the closest being the inventoried roadless areas on the Sumter National Forest several hundred miles away.

15.2.3.3 Current Management

There is Forestwide direction to maintain the roadless areas. Roadless areas are adjacent to wilderness and provide for isolation, solitude, and more primitive experiences. The inventoried roadless areas are located within management area 29 of the Forest plan. The goals of that management area are to “provide an area on the Forest that is characterized by semi-primitive, motorized recreation opportunities” and to “link wilderness areas with similar ecological units to minimize landscape fragmentation”. An objective of this management area is to maintain the roadless area values of the roadless areas. Many typical Forest management actions are not allowed or limited in these areas, such as road building, herbicide use, recreational site development, and wildlife openings.

15.2.3.4 Risks/Uncertainties/Trends

There is no specific monitoring of these areas currently. There may be need for additional information on conditions and use within the areas.

15.2.4 Swamp Fox National Recreation Trail

15.2.4.1 Current Conditions

The 51-mile Swamp Fox National Recreation Trail was designated in 1979 as a national recreation trail. National recreation trails may be designated by the Secretary of Interior or the Secretary of Agriculture to recognize exemplary trails of local and regional significance in response to an application from the trail's managing agency or organization. Through designation, these trails are recognized as part of America's national system of trails. Informal use numbers collected via trail and traffic counters indicate several thousand uses all or portions of this trail each year.

A portion of the Swamp Fox Trail was also designated as the Swamp Fox Passage of the Palmetto Trail. This federally designated millennium legacy trail is one of only 16 cross-state trails in the United States. The Swamp Fox Passage is currently the longest section of the cross-state trail. The Awendaw Passage of the Palmetto Trail offers another 7 miles and is the coastal terminus of the Palmetto Trail, ending at the Intracoastal Waterway.

15.2.4.2 Broader Landscape

Trails and trail systems continue to gain in popularity and use, with examples such as the Palmetto Trail, the East Coast Greenway, and the Southeast Coast Saltwater Paddling Trail. These are examples of multi-jurisdictional, multi-partnered trails that continue to make connections from urban centers to rural area and beyond.

15.2.4.3 Current Management

The Swamp Fox Trail meanders through multiple management areas including 26, 27, and 28. There is no specific direction in any of those management areas related to national recreation trail. The 1996 Francis Marion Revised Land and Resource Management Plan does have specific visual quality objectives for the trail corridor.

15.2.5 Santee Experimental Forest

15.2.5.1 Current Conditions

The Santee Experimental Forest was designated for research by the Chief of the Forest Service in July of 1937. The experimental forest is located in Berkeley County, South Carolina, and is comprised of 6,053 acres within the Francis Marion National Forest.

The Santee Experimental Forest research operations are guided by the Southeastern Forest Experiment Station. Research is centered on the ecology and management of forested wetland ecosystems in the South Atlantic Coastal Plain.

The Santee Experimental Forest provides a hydrologic laboratory, long-term studies, experimental facilities, diverse forest types, and demonstration areas that are designed to provide a basis for enhancing the management, restoration, and conservation of the South Atlantic Coastal Plain forested landscape. The lands comprising the Santee are characterized as a mosaic of pine hardwood flatwoods and wetlands along the streams and ephemeral drainages. Located

in Berkley County, South Carolina, the Santee encompasses some of the oldest colonized lands in the United States. The land was originally granted to Thomas Colleton in 1683 and formed into the 12,000-acre Cypress Barony. The land was divided in 1709 and subsequently incorporated part of the early, large plantations in coastal South Carolina. The uplands was cleared for agriculture and used for naval stores production, and the bottomlands were used for rice and indigo cultivation. After the collapse of the rice industry, the land was placed into timber production and logged heavily between 1897 and the late 1920s. In 1933 the land was acquired by the U.S. government, and the Francis Marion National Forest was formed in 1936. A year later the Santee Experimental Forest was established.

The original purpose of the Santee was to address thinning and fire management in loblolly pine stands. Research there evolved to include silviculture, soil-site relationships, and forest hydrology. Presently, the Santee encompasses 2,469 hectares, containing all the major forest types in the Lower Coastal Plain, three gauged watersheds, a hydroedaphytron facility, and laboratory and housing facilities (Adams et al. 2004).

15.2.5.2 Current Management

The 1996 Forest plan allocates this area to management area 4 which provides management direction in terms of goals, desired future conditions, objectives, standards and guidelines.

Fire suppression, prescribed fire, roads management, timber salvage, recreation and special uses management within the experimental forest is managed by the Francis Marion National Forest in coordination with experimental forest staff.

Wildlife management within the Santee Experimental Forest is conducted in cooperation with Francis Marion district staff (habitat) and South Carolina Department of Natural Resources (SCDNR) managing wildlife species and regulating hunting/fishing seasons and limits.

Forest management of non-study areas of the Santee Experimental Forest is included in the land and resource management plan of the Francis Marion National Forest. The main objective of the Forest Service's forest management program is to ensure that the national forests are managed in an ecologically sustainable manner (USDA website, accessed 2013). In the past the National Forests vision included multiple objectives: to improve and protect the forest, to secure favorable watershed conditions, and to furnish a continuous supply of timber for the use of citizens of the United States. The current objectives have evolved to include ecological restoration and protection, research and product development, fire hazard reduction, and the maintenance of healthy forests. Guided by law, regulation, and Agency policy, Forest Service forest managers use timber sales, as well as other vegetation management techniques such as prescribed fire, to achieve these objectives. These activities have captured substantial public attention, and in some cases, have become hotly debated (USDA Website, accessed 2013).

15.2.6 Research Natural Area

15.2.6.1 Existing Information

This section is under further development.

Guilliard Lake Research Natural Area is an area of remnant old growth located in bottomland along the Santee River. The 23 acres is in Berkeley County, South Carolina, and is maintained as a somewhat virgin stand between Jamestown and the Atlantic Ocean. Guilliard Lake Research Natural Area was established by the Chief of the Forest Service in November 1963.

15.2.6.2 Current Conditions and Trends

This research natural area should continue to serve as a baseline area for the research of cypress-tupelo forest type.

Fire suppression, prescribed fire, roads management, timber salvage, recreation and special uses management within the research natural area are managed by the Francis Marion National Forest in coordination with experimental forest staff.

Wildlife management within the Guillard Lake Research Natural Area is conducted in cooperation with Francis Marion district staff (habitat) and South Carolina Department of Natural Resources (SCDNR) managing wildlife species and regulating hunting/fishing seasons and limits.

Opportunities exist for occasional proposals for research or monitoring to be conducted by academic institutions. As relevant, special use permits may be issued and results shared with the National Forest at termination of data collection.

15.2.6.3 Information Needs

There is a need for continued baseline monitoring of current conditions.

15.3 Regional Forest Designated Areas

15.3.1.1 Preliminary Findings

►Management area 8 was developed to contain areas that hold unique characteristics (geologic, botanical, scenic, or historical) that require special management consideration to ensure the perpetuation of their unique value. The Forest has multiple regional forester designated areas such as botanical areas, geological areas, scenic areas, and historic areas totaling over 6,473 acres. This management area acknowledges that special management consideration is required to ensure the perpetuation of their unique values.

►**Historical Areas.** According to Forest Service archeologists, there is a need to change the amount and size of areas that are designated as historic. Since 1996, knowledge of the Forest's history continues to grow and new information identifies new areas, changes the boundaries of existing areas, and occasionally drops areas. There is a need to add special historical designated areas such as the Salt Pond Tract (which includes Sewee Shell Ring), Walnut Grove area, the area south of Awendaw Creek, Wythewood Plantation and Clayfield Plantation. There may be others that would warrant special designations.

►**Botanical, Geological, and Research Natural Areas.** Since 1996, knowledge of the Forest vegetation continues to grow and new information identifies additional areas, changes the boundaries of existing areas, and may occasionally drop areas. According to Forest Service specialists there is a need to change the amount, distribution, and size of areas that are designated as botanical areas.

►**Scenic Areas.** The 1996 Forest plan identifies two scenic areas in management area 8.

- Cedar Hill Island, an 800-acre island between the Santee and Chicken Creek, mostly a mature swamp hardwood forest with scattered pines along a natural levee.

- The 1,041-acre Guillard Lake Scenic Area was established by the Chief of the Forest Service in 1963 to preserve the scenic qualities of the areas. This scenic area also surrounds the 18-acre Guillard Lake Research Natural Area.

According to data gathered in the public meetings and Crowdbrite on-line commenting session, iconic and scenic places on the Francis Marion abound, with the Longleaf Pine Ecosystem and Carolina Bays and Hardwood Swamps at the top of the list. The diversity of the coastal ecosystem was mentioned often.

►**Wild and Scenic River.** Based on the 1996 Revised Forest Plan Final Environmental Impact Study, appendix E, the Santee River is eligible for study as a wild and scenic river. Eligibility is a qualification of a river for inclusion in the national system through determination that it is free-flowing and has at least one outstandingly remarkable value. A determination that a particular river is eligible for designation does not necessarily imply that it is suitable for designation. A suitability analysis can be done during the Forest planning process.

15.3.2 Historical Areas

15.3.2.1 Current Conditions

Sewee Shell Ring

There are three historic sites within management area 8, Battery Warren Historical Site, Sewee Shell Mound, and Waterhorn Plantation. The Battery is an earthen civil war fortification consisting of 20-foot high and 300-feet long with excavated areas along the river for gun emplacements. The trail system and signage at the Battery needs improvement. Sewee Shell Ring is a prehistoric shell midden. After a recent hurricane, the trail, boardwalk and signs were replaced. The only significant historical research has been within the last year at Sewee Shell Ring; it is listed on the National Register of Historic Places. Waterhorn Plantation is the site of one of the first plantations on the Santee River. A battle between General Francis Marion and British troops was fought here in 1782. These areas are currently in good condition.

15.3.2.2 Risk and Uncertainties

There is a risk of detection and theft by very active metal detector use on the Forest in general and within the management area 8 in particular. There is a need for more law enforcement where known activity is occurring. More monitoring for illegal use is needed.

15.3.2.3 Past, Likely and Future Trends

There is a need to add special historical designated areas such as the Salt Pond Tract (which includes Sewee Shell Ring), Walnut Grove area, the area south of Awendaw Creek, Wythewood Plantation and Clayfield Plantation. There may be others that would warrant special designations. There is no interpretation in any of these sites areas currently. Trends would be to make better use of the areas through interpretation and visitor information.

15.3.2.4 Broader Landscape

There is great potential for more interpretation of historical sites and landscapes across the Forest as the Lowcountry of South Carolina is a treasure trove of history and cultures. One example of

this is the Gullah Geechee Cultural Heritage Corridor. Designated by Congress in 2006 the corridor extends from Wilmington, North Carolina, in the north to Jacksonville, Florida, in the south. It is home to one of America's most unique cultures—a tradition first shaped by captive Africans brought to the southern United States from West Africa and continued in later generations by their descendants. The Francis Marion is within this corridor.

15.3.3 Botanical Areas, Geological and Research Natural Areas

15.3.3.1 Changing Conditions

Management area 8 was developed to contain areas that hold unique characteristics (geologic, botanical, scenic, or historical) that require special management consideration to ensure the perpetuation of their unique value. A standard MA8-2 stated, "[F]or areas identified in the Inventory of Unique Natural Areas, follow management recommendations for botanical areas within that document." Botanical areas addressed in the 1996 revised plan, page 4-9, included 60 areas identified in the Inventory of Unique Natural Areas (Porcher 1982, 1991, 1993), Honey Hill Limesink Area, I'on Swamp, and Tibwin Plantation.

Monitoring of all 60 natural areas has been conducted (Porcher 1991; Everett 2012), several have degraded and some no longer warrant botanical area designation, or they need to be remapped, either because their condition has changed, or because they represent rare plant populations only. Several new areas with rare plant communities or at-risk plant habitats requiring special management attention can now be recognized (Forest Rare Community and TESP Habitat GIS Coverage, ongoing). Neither I'on Swamp nor Tibwin Plantation contains significant rare botanical species or plant communities, but they are significant for both histories on the Forest and to wildlife.

The Forest has two research natural areas, both designated in 1993, which were not addressed in the Forest plan. The Guilliard Lake Research Natural Area totals 18 acres (roughly mapped in FSVEG east of the scenic area as C.119, St.12 [though this stand is 32.4 acres, compared to the 18 acres designated]), and Little Wambaw Swamp Natural Area totals 60 acres (a precise square, included within Little Wambaw Swamp Wilderness). Although Honey Hill was proposed as a research natural area in the 1996 revised plan, it was never officially designated.

In the revised Sumter National Forest Plan (2006) botanical areas were created for public use and enjoyment and a rare community prescription was created to harbor elements of biological diversity requiring special management attention.

15.3.3.2 Broader Landscape

Botanical areas can harbor significant components of natural diversity requiring special management attention. At state and national levels, biodiversity is maintained within networks of state heritage preserves, maintained by the state natural heritage programs, and by the Nature Conservancy.

The research natural area designation is part of a national Forest Service-wide network of ecological areas used for research and education. As of 1993, the U.S. Forest Service has managed 289 established RNAs and more than 300 candidate RNAs, nationally.

15.3.3.3 Past and Likely Future Trends

Only a few of the botanical areas, namely the mixed mesic hardwood communities, suffered damage from Hurricane Hugo (Porcher 1991). Several botanical areas occur in the wildland-

urban interface, and since 1996, have declined in quality due to lack of prescribed fire (Everett 2012). Management recommendations referred to in MA8-2, including maintenance with prescribed burning, and sometimes annual burning, has been inconsistently followed since 1996. Other natural areas have declined from invasion by nonnative invasive species, and some management activities have occurred to control them (Tibwin, Guilliard Lake Scenic Area, I'on Swamp).

As a result of monitoring efforts we have gained new information on management needs. For instance at Honey Hill, restoration efforts there have been proposed to include restoration of longleaf pine, and more active management of the endangered pondberry which occurs at this site (Glitzenstein 2007).

Future trends are likely to continue under current Forest plan direction. Several areas contain significant components of biodiversity, but will need to be managed to maintain or restore those characteristics in the future.

15.3.3.4 Uncertainties

Our ability to prescribe burn and restore and maintain unique natural areas is compromised by uncertain weather patterns and public safety concerns. Our ability to control nonnative invasive species is also uncertain. Monitoring to detect population changes and response to management needs over time, is needed, as is better coordination to ensure that a diversity of botanical areas is maintained and managed in the future.

15.3.4 Scenic Areas

15.3.4.1 Current Conditions

The Forest plan identifies two scenic areas in management area 8. Cedar Hill Island, an 800-acre island between the Santee and Chicken Creek, is mostly a mature swamp hardwood forest with scattered pines along a natural levee. Another scenic area is the 1041-acre Guillard Lake Scenic Area, established by the Chief of the Forest Service in 1963, to preserve the scenic qualities of the areas. The scenic area also surrounds the 18-acre Guillard Lake Research Natural Area. According to data gathered in the public meetings and Crowdbrite on-line commenting session, iconic and scenic places on the Francis Marion abound, with the Longleaf Pine Ecosystem and Carolina Bays and Hardwood Swamps at the top of the list. The diversity of the coastal ecosystem was mentioned often.

15.3.4.2 Current Management

The goal of the management area is to ensure the protection of significant historical, scenic, and unique geologic values, and to preserve the unique values of specific botanical areas for biological diversity. There are no objectives for the management area. The desired conditions states that in historic and scenic areas, visitation and recreation are encouraged with interpretative materials and devices available to the public.

15.3.4.3 Risks/Uncertainties/Trends

There are no known risks in scenic area designation, and there is no current trend information. There are no identified scenic areas that showcase the mostly readily identifiable and most often mentioned ecosystems, longleaf pine, bays, and swamps.

15.3.5 Eligible Wild and Scenic Rivers

15.3.5.1 Current Conditions

Congress passed the National Wild and Scenic Rivers System Act in 1968 for the purpose of preserving rivers with outstanding natural, cultural, and recreational values in a free-flowing condition for the enjoyment of present and future generations. The Act is recognized for safeguarding the special character of these rivers, while also allowing for their appropriate use and development. The Act promotes river management across political boundaries and public participation in developing goals for river protection.

No wild and scenic rivers are currently designated for the Francis Marion National Forest.

Based on the inventory information in the 1996 Forest plan, the Santee River is eligible for inclusion (see FEIS, appendix E). Eligibility is a qualification of a river for inclusion in the national system through determination that it is free-flowing and has at least one outstandingly remarkable value. A determination that a particular river is eligible for designation does not necessarily imply that it is suitable for designation. A suitability analysis can be done during the Forest planning process. No Forestwide assessment of rivers was found in the project file of the 1996 Forest plan.

15.3.5.2 Current Management

The Santee River's outstandingly remarkable values are not mentioned in the Francis Marion plan and direction for protection of those values is generally included in management practices for the surrounding areas. The majority of the river is located in management areas 26 and 27.

15.3.5.3 Broader Landscape

The Santee River was considered inventoried and studied in the South Carolina Rivers Assessment, which assessed over 11,000 miles of rivers in the State. The study was designed to become a consistent information base for use in decision-making about river resources in the State. Several rivers on the Francis Marion were included, including the Santee River, Wambaw Creek, Wando River, and Echaw Creek.

15.3.5.4 Risks/Uncertainties/Trends

No identified outstandingly remarkable value was documented in the Forest plan or process record for the Santee River.

15.4 Administrative Sites

15.4.1.1 Preliminary Findings

►**Seed Orchard and Progency Test Areas.** There are currently 719 acres designated at the Seed Orchard. There is the potential to reclassify portions of this site to include coincident uses such as potential U.S. Marine Corp landing zone and current helibase site as well as reclassify vegetative types within the area based on future need and management direction. The area is currently designated management area 1 in the revised Francis Marion FLRMP and is to be managed with direction found in the Tree Improvement Handbook, FSH 2475 and FSM 2475 (Genetic Resource Management, updated 2012).

►**Francis Marion Office and Ranger Station.** The administrative site for the Francis Marion Ranger District encompasses approximately 14 acres and has the potential for a work center on site.

►**Witherbee Office, Work Center and Housing Complex.** There is potential for all or a portion of the compound's 16 acres (including government housing, annex) to be redesignated to another management area based on the decommissioning and removal of facilities in this area.

15.4.2 Seed Orchard and Progeny Test Areas

15.4.2.1 Existing Information

The area is currently designated management area 1 in the revised Francis Marion FLRMP and is to be managed with direction found in the Tree Improvement Handbook, FSH 2475 and FSM 2475 (Genetic Resource Management, updated 2012). Specific objectives are determined by Region 8 Genetics Management Program guidelines.

The Francis Marion Seed Orchard (616 acres) and Progeny Site (33 acres) make up 719 acres in the Francis Marion National Forest. The area is accessed from North Hampton Road (Forest Service Road 170) near State Highway 41 in the Huger area of Berkeley County, South Carolina. Within this acreage, a designated helibase is staffed seasonally and as necessary to support the Forest prescribed fire program and wildland firefighting efforts (see Section 11 "Infrastructure", for more detail).

15.4.2.2 Current Conditions and Trends

The area is located on loamy ridges and is predominantly open land with planted trees and native grass materials. The progeny sites are small areas planted scattered throughout the site. The site currently includes a helibase with associated support building and constructed helipads.

Over the past decade, there has been a reduced need to supply other forests and agencies with seeds, seedlings, and superior tree material from this orchard. However, the seed orchard is being maintained as a conservation bank for existing material and for future tree conservation species seed production. This supports the longleaf pine and oak initiatives. The seed orchard also provides a location to study and grow native grasses.

The site is managed through use of prescribed fire, mowing and disking. Support facilities include an office area, communications tower, storage sheds and storage facilities.

The site has been designated an auxiliary work center for storage of Forest resources since the sale and conveyance of the Wambaw Ranger Station and Work Center.

There has been a recent request by the U.S. Marine Corps Camp Lejeune to consider a minimum of 5 acres for a temporary landing zone for the MV-22 Osprey. A decision has yet to be made on the temporary permit request. There has also been discussion to consider a long-term permit for the above activity at this same site.

15.4.2.3 Information Needs

There is a need for continued baseline monitoring and documentation of current conditions at this site (including seed orchard, progeny sites and helibase). This should include shifts in resources, management direction, and support in operations of the site.

15.4.3 Francis Marion Office and Ranger Station

15.4.3.1 Existing Information

This serves as the administrative headquarters for the Francis Marion Ranger District. The Francis Marion Office/Ranger Station is located at 2967 Steed Creek Road in Huger, South Carolina. The 14-acre site provides a 5-acre office setting for Forest employees and volunteers, employee and visitor parking, fleet parking, and a paint building to support the district timber sale program. The site also includes supporting entrance road, water and electric lines, septic system/drain fields and communications tower (see Section 11, "Infrastructure", for more detail).

15.4.3.2 Current Conditions and Trends

The site is flat and loamy with loblolly pines and associated hardwoods as the predominant forest species in the adjacent wooded area. The office was constructed to co-locate two former offices with duplicated services and expenses. The office site is managed through periodic mowing and maintenance of various ornamental trees, shrubs and plants.

The designation of 14 acres, including the 5-acre office site, supports the construction of a future work center for the Francis Marion Ranger District. When funds become available for work center construction, the current Witherbee Work Center on Witherbee Road will be phased out. Currently, the function of a district work center is being carried out at the Witherbee Work Center and Seed Orchard.

15.4.3.3 Information Needs

Evaluate the need for "hardened parking" for transports and dozers as well as circular driveway for vehicles hauling boats and trailers and delivery vehicles.

15.4.4 Witherbee Office, Work Center and Housing Complex

15.4.4.1 Existing Information

The Witherbee Office, Work Center and government housing complex is located in Berkeley County on 2421 Witherbee Road, Cordesville, South Carolina. The approximate 16-acre site can be considered three separate units: office area (4 acres), work center area (4 acres), and government housing Area (8 acres) (see Section 11, "Infrastructure", for more detail).

15.4.4.2 Current Conditions and Trends

The former Witherbee office and annex are not currently occupied. They now serve as storage until a determination is made to sell the buildings, tear them down, or convert the annex into temporary housing. The Witherbee Office is currently being used as storage and has been considered alternate housing for seasonal hires or an emergency command post.

The complex currently has four government houses that have been decommissioned. The areas around the houses have been kept mowed and cleared of brush until a decision is made to sell the structures or tear them down. Consideration for conversion of the house sites to volunteer campsites has been discussed.

The Witherbee Work Center is currently used as a work center for the Francis Marion Ranger District until a decision to construct a new work center at the Francis Marion office site on Steed Creek Road has been made. When a new work center is constructed, the Witherbee Work Center will be decommissioned.

15.4.4.3 Information Needs

Conduct a facilities analysis to determine the future use or disposal of decommissioned facilities and structures.

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http://www.dnr.sc.gov/cwcs/pdf/habitat/CoastalPlainAquatics.pdf

http://www.dnr.sc.gov/pubs/CCINatResReport.pdf

http://www.dnr.sc.gov/water/envaff/aquatic/snail.html

http://www.fs.fed.us/ccrc/topics/aquatic-ecosystems/warmwater-aquatic-fauna.shtml#f-tabs-5

Appendix A: Plants of Potential Conservation Concern and At-Risk on the Francis Marion National Forest

Note: Global, State, Number of Forest EORs or Revisits, and Unit Rank – where U1 = Critically imperiled, 5 or fewer occurrences; U2 = Imperiled, 5–20 occurrences; and U3 = Vulnerable, 30–80 occurrences.

Table A-1. Plants of potential conservation concern on the Francis Marion National Forest

Element_Name	Common_Name	G_Rank (rounded)	S_Rank	Number of Occurrences on the Forest	Unit_ Rank
Agalinis aphylla	Coastal Plain False-foxglove	G3	S1	1	U1
Agrimonia incisa	Incised Groovebur	G3	S2	6	U2
Andropogon gyrans var. stenophyllus	Elliott's Bluestem	G4Q	S1	1	U1
Anthaenantia rufa	Purple Silkyscale	G5	S2	3	U1
Asclepias pedicellata	Savanna Milkweed	G4	S2	3	U1
Asplenium heteroresiliens	Wagner's Spleenwort	G5	S1	1	U1
Asplenium resiliens	Black-stem Spleenwort	G5	S1	1	U1
Burmannia biflora	Northern Burmannia	G4	S2	2	U1
Calopogon barbatus	Bearded Grass-pink	G4	S2	3	U1
Calopogon multiflorus	Many-flower Grass-pink	G2	S1	2	U1
Carex basiantha	Widow sedge	G5	S2?	1	U1
Carex chapmanii	Chapman's Sedge	G3	S1	1	U1
Carex crus-corvi	Ravenfoot Sedge	G5	S2	1	U1
Carex elliottii	Elliott's Sedge	G4	S1	2	U1
Carex granularis	Meadow Sedge	G5	S2	1	U1
Carex stricta	Tussock Sedge	G5	S1	1	U1
Carya myristiciformis	Nutmeg Hickory	G4	S2	6	U2
Chamaedaphne calyculata	Leather-leaf	G5	SNR	1	U1
Chasmanthium nitidum	Shiny Spikegrass	G3	S1	1	U1
Cladium mariscoides	Twig-rush	G5	S1	1	U1
Coreopsis gladiata	Southeastern Tickseed	G4G5	SNR	8	U2
Coreopsis integrifolia	Chipola Dye-flower	G1G2	S1	1	U1
Eleocharis tricostata	Three-angle Spikerush	G4	S2?	3	U1
Eryngium aquaticum var.ravenelii	Ravenel's Eryngo	G2	S1	2	U1
Eupatorium anomalum	Florida Thorough-wort	G2	S1?	1	U1
Eupatorium recurvans	Coastal-plain Thorough-wort	G3	S1?	1	U1
Helenium pinnatifidum	Southeastern Sneezeweed	G4	S2	5	U2
Lachnocaulon minus	Small's Bogbutton	G3G4	S1	1	U1
Listera australis	Southern Twayblade	G4	S2?	2	U1
Litsea aestivalis	Pondspice	G3	S3	56	U3

Element_Name	Common_Name	G_Rank (rounded)	S_Rank	Number of Occurrences on the Forest	Unit_ Rank
Lobelia boykinii	Boykin's Lobelia	G2	S3	12	U2
Ludwigia lanceolata	Lance-leaf Seedbox	G3	S1	1	U1
Lysimachia hybrida	Lance-leaf Loosestrife	G5	S1	4	U1
Lysimachia loomisii	Loomis' Loosestrife	G3	SNR	1	U1
Macbridea caroliniana	Carolina Bird-in-a-nest	G2G3	S3	6 (experimental)	U1
Matelea flavidula	Carolina Milkvine	G4?	SNR	2	U1
Myriophyllum laxum	Piedmont Water-milfoil	G3	S2	1	U1
Oenothera riparia	Riverbank Evening- primrose	G2G3	SNR	Likely	U1
Parnassia caroliniana	Carolina Grass-of-parnassus	G3	S2	1 Introduced	U1
Peltandra sagittifolia	Spoon-flower	G3	S2	2	U1
Pieris phillyreifolia	Climbing Fetter-bush	G3	S1	7	U2
Plantago sparsiflora	Pineland Plantain	G3	S2	7	U2
Platanthera integra	Yellow Fringeless Orchid	G3	S1	9	U1
Ponthieva racemosa	Shadow-witch Orchid	G4	S2	6	U1
Pteroglossapsis ecristata	Crestless Plume Orchid	G2	S2	12	U2
Quercus similis	Bottom-land Post Oak	G4	S1	2	U1
Rhexia aristosa	Awned Meadowbeauty	G3	S3	22	U3
Rhynchospora breviseta	Short-bristle Baldrush	G3	S1	6	U2
Rhynchospora cephalantha var. attenuata	Small bunched Beak Sedge	G?	S?	1	U1
Rhynchospora globularis var. pinetorum	Beakrush	G3	S1	3	U1
Rhynchospora harperi	Harper Beakrush	G4	S1	1	U1
Rhynchospora inundata	Narrow-fruit Horned Beaksedge	G4?	S2?	5	U2
Rhynchospora oligantha	Few-flowered Beaked-rush	G4	S2	3	U1
Rhynchospora pleiantha	Brown Beaked-rush	G2	S1	1	U1
Rhynchospora scirpoides	Long-beaked Beaksedge	G4	S1	3	U1
Rhynchospora stenophylla	Chapman Beakrush	G4	S2	1	U1
Ruellia strepens	Limestone Petunia	G4	S1	1	U1
Sageretia minutiflora	Tiny-leaved Buckthorn	G4	S3	2	U1
Sarracenia rubra var.rubra	Sweet Pitcher-plant	G3	S3S4	11	U2
Sida elliotti	Elliott's Fanpetals	G4G5	SNR	1	U1
Spiranthes laciniata	Lace-lip Ladies'-tresses	G4	S1S2	7	U2
Sporobolus curtisii	Pineland Dropseed	G3	S1	7	U2

Element_Name	Common_Name	G_Rank (rounded)	S_Rank	Number of Occurrences on the Forest	Unit_ Rank
Sporobolus pinetorum	Carolina Dropseed	G3	S2	5	U1
Tridens caroliniansis	Carolina Fluff Grass	G3	S1	14	U2
Tridens chapmanii	Chapman's Redtop	G5T3	S1	1	U1
Triphora trianthophora	Threebirds Orchid	G3G4	S2	2	U1
Utricularia macrorhiza	Greater Bladderwort	G5	S1	1	U1
Xyris brevifolia	Short-leaved Yellow-eyed Grass	G4	S1	1	U1
Xyris difformis var. floridana	Florida Yellow-eyed Grass	G4	S2	1	U1
Xyris elliottii	Elliott Yellow-eyed Grass	G4	S2	10	U2
Xyris flabelliformis	Savannah Yellow-eyed Grass	G4	S1	1	U1
Xyris stricta	Pineland Yellow-eyed Grass	G4	SNR	1	U1

Table A-2. At-risk plants by species group

Species Group	Location or AA on the Forest, if Restricted in Distribution	Threats
Non-Riverine Swamp and Wet Hardwood Forest Species		
Chasmanthium nitidum	C149 Complex	Feral hogs, plantation management
Eupatorium anomalum	Wando-Ion	Sea level rise, feral hogs, plantation management
Pieris phyllyreifolia		Sea level rise, feral hogs
Ruellia strepens	Macedonia	Feral hogs, plantation management
Calcareous Mesic Slope Hardwood Forests		
Carex basiantha	North-facing slopes of Huger Creek	Non-native invasive plant species, , plantation management, feral hogs
Carex granularis	North-facing slopes of Huger Creek	Non-native invasive plant species, feral hogs, plantation management
Matelea flavidula	Guilliard C Marl Forest; Wambaw Creek Slopes	Sea level rise, non-native invasive plant species, feral hogs, plantation management
Triphora trianthophora		Non-native invasive plant species, feral hogs, plantation management
Calcareous Blackwater Stream and River Floodplain Forests		
Carex chapmanii	Turkey Creek Streambank	Feral hogs, plantation management
Carex crus-corvi	Echaw Creek Botanical Area (near confluence with Santee River); Guilliard C Marl Forest	Sea level rise, non-native invasive plant species, feral hogs, plantation management
Carex elliottii	Red Bluff Creek floodplain	Feral hogs, non-native invasive plant species,
Carya myristiciformis	Nicholson, Turkey, and Huger Creek floodplains	Feral hogs, non-native invasive plant species, plantation management
Listera australis	Little Wambaw Swamp Natural Area, Huger Creek, also found in calcareous mesic forests	Feral hogs, non-native invasive plant species, plantation management
Oenothera riparia		Sea level rise, non-native invasive plant species, feral hogs, succession

Species Group	Location or AA on the Forest, if Restricted in Distribution	Threats
Ponthieva racemosa		Feral hogs, non-native invasive plant species, , roads and rights-of-way, plantation management, off-road vehicles
Quercus similis		Feral hogs, non-native invasive plant species, plantation management
Marl Outcrops and Maritime Shell Forests		
Asplenium heteroresiliens	Santee River Marl Outcrop - Guilliard Lake Scenic Area	Sea-level rise, non-native invasive plant species
Asplenium resiliens	Santee River Marl Outcrop - Guilliard Lake Scenic Area	Sea-level rise, non-native invasive plant species, dams and water management
Sageretia minutiflora	Sewee Shell Mound	Sea-level rise, non-native invasive plant species, recreation use
Pond Cypress Savanna-Dominated Carolina Bays and Depression Ponds		
Andropogon gyran var. stenophyllus	Halfway Creek Road Pond Cypress Savanna	Succession, lack of frequent fire, non-native invasive species
Burmannia biflora	Honey Hill Limesinks, Halfway Creek Road Pond Cypress Savanna	Succession, lack of frequent fire, feral hogs
Eleocharis tricostata		Succession, feral hogs
Eupatorium recurvans		Succession, lack of frequent fire, feral hogs
Helenium pinnatifidum		Succession, lack of frequent fire, feral hogs
Lindera melissifolia		Succession, lack of frequent fire, feral hogs
Litsea aestivalis		Succession, non-native invasive species, feral hogs
Lobelia boykinii	Florida Bay, Echaw Road Bay, Tibwin Bay, McConnell Sink	Succession, non-native invasive species, off-road vehicles, feral hogs
Myriophyllum laxum		Succession, drought, climate change
Oxypolis canbyi		Succession, lack of frequent fire, feral hogs
Rhexia aristosa		Succession, lack of frequent fire, illegal off-road vehicles, feral hogs
Rhynchospora harperi	Florida Bay	Succession, lack of frequent fire, illegal off-road vehicles, feral hogs
Rhynchospora inundata		
Rhynchospora pleiantha	Florida Bay	Succession, lack of frequent fire, illegal off-road vehicles, feral hogs
Rhynchospora scirpoides	Florida Bay	Succession, lack of frequent fire, illegal off-road vehicles, feral hogs
Spiranthes laciniata		Succession, lack of frequent fire, feral hogs
Utricularia macrorhiza		Succession, lack of frequent fire, feral hogs
Xyris difformis var. floridana		Succession, lack of frequent fire, feral hogs

Species Group	Location or AA on the Forest, if Restricted in Distribution	Threats
Xyris elliottii		Succession, lack of frequent fire, feral hogs
Xyris flabelliformis		Succession, lack of frequent fire, feral hogs
Seepage Slopes, Pocosins, and Non-Riverine Swamp Ecotones		
Asclepias pedicellata	Florida Bay, Red Bluff Bay	Climate change, lack of frequent fire, succession, feral hogs
Carex elliottii	Red Bluff Creek Seepage Slopes	Succession, lack of frequent fire, feral hogs
Chamaedaphne calyculata	Little Ocean Bay	Succession, lack of frequent fire, feral hogs
Coreopsis integrifolia	Seepage Slopes, Ecotone w/upland longleaf along tributary of Morgan and Red Bluff Creek	Succession, lack of frequent fire, feral hogs
Lysimachia loomisii		Succession, lack of frequent fire, feral hogs
Macbridea caroliniana		Succession, roads and rights-of-way
Peltandra sagittifolia		Succession, lack of frequent fire, feral hogs
Rhynchospora cephalantha var. attenuata	Morgan Branch Seepage Slope	Succession, lack of frequent fire, feral hogs
Rhynchospora stenophylla	Morgan Branch Seepage Slope	Succession, lack of frequent fire, feral hogs
Sarracenia rubra ssp. rubra		Collection of plants, succession, lack of frequent fire, feral hogs
Dry to Mesic Phase Upland Longleaf Pine Woodlands		
Agrimonia incisa		Plantation management, roads and right-of-way, non-native invasive plant species, feral hogs
Pteroglossaspis ecristata		Lack of frequent fire, non-native invasive plant species, feral hogs, plantation management
Schwalbea americana		Lack of frequent fire, non-native invasive plant species, feral hogs, plantation management
Tridens carolinianus		Lack of frequent fire, non-native invasive plant species, feral hogs, plantation management
Tridens chapmanii		Lack of frequent firenon-native invasive plant species, feral hogs, plantation management
Mesic to Wet Phase Pine Savannas and Flatwoods		
Agalinis aphylla	C.37-Gumville Road Savanna	Lack of frequent firenon-native invasive plant species, feral hogs, plantation management
Anthaenantia rufa	C.96 Savanna	Lack of frequent fire, non-native invasive plant species, feral hogs, plantation management
Asclepias pedicellata		Lack of frequent fire, non-native invasive

Species Group	Location or AA on the Forest, if Restricted in Distribution	Threats
		plant species, feral hogs, plantation management
Calopogon barbatus		Collection of plants, Lack of frequent fire, non-native invasive plant species, feral hogs, plantation management
Calopogon multiflorus		Collection of plants, Lack of frequent fire, non-native invasive plant species, feral hogs, plantation management
Carex stricta		Lack of frequent fire, non-native invasive plant species, feral hogs, plantation management
Cladium mariscoides		Lack of frequent fire, non-native invasive plant species, feral hogs, plantation management
Coreopsis gladiata		Lack of frequent fire, non-native invasive plant species, feral hogs, plantation management
Lachnocaulon minus		Lack of frequent fire, non-native invasive plant species, feral hogs, plantation management
Lysimachia hybrida		Lack of frequent fire, roads and road rights-of-ways, plantation management
Ludwigia lanceolata		Lack of frequent fire, non-native invasive plant species, feral hogs, plantation management
Platanthera integra		Lack of frequent fire, non-native invasive plant species, feral hogs, plantation management, illegal collections
Rhynchospora breviseta	Awendaw savanna, Florida bay	Lack of frequent fire, non-native invasive plant species, feral hogs, illegal off-road vehicles, plantation management
Rhynchospora globularis var. pinetorum		Lack of frequent fire, non-native invasive plant species, feral hogs, plantation management
Rhynchospora oligantha	Wardfield Savanna, Morgan Branch Seepage Slope	Lack of frequent fire, non-native invasive plant species, feral hogs, plantation management
Sporobolus curtissii	Gumville Savannas (C36,37,38)	Lack of frequent fire, non-native invasive plant species, feral hogs, plantation management
Sporobolus pinetorum	C.138,140,143	Lack of frequent fire, non-native invasive plant species, feral hogs, plantation management
Xyris stricta	Awendaw savanna	Lack of frequent fire, non-native invasive plant species, feral hogs, plantation management
Wet Marl Savannas		
Eryngium aquaticum var. ravenelii		Lack of frequent fire, non-native invasive plant species, feral hogs, plantation management
Parnassia caroliniana		Lack of frequent fire, non-native invasive plant species, feral hogs, plantation

Species Group	Location or AA on the Forest, if Restricted in Distribution	Threats
		management
Plantago sparsiflora		Lack of frequent fire, non-native invasive plant species, feral hogs, roads and rights-of-ways, plantation management
Sida elliottii		Lack of frequent fire, non-native invasive plant species, feral hogs, roads and rights-of-ways, plantation management

Appendix B: Trends, Core Area, and Other Information for the Red-cockaded Woodpecker

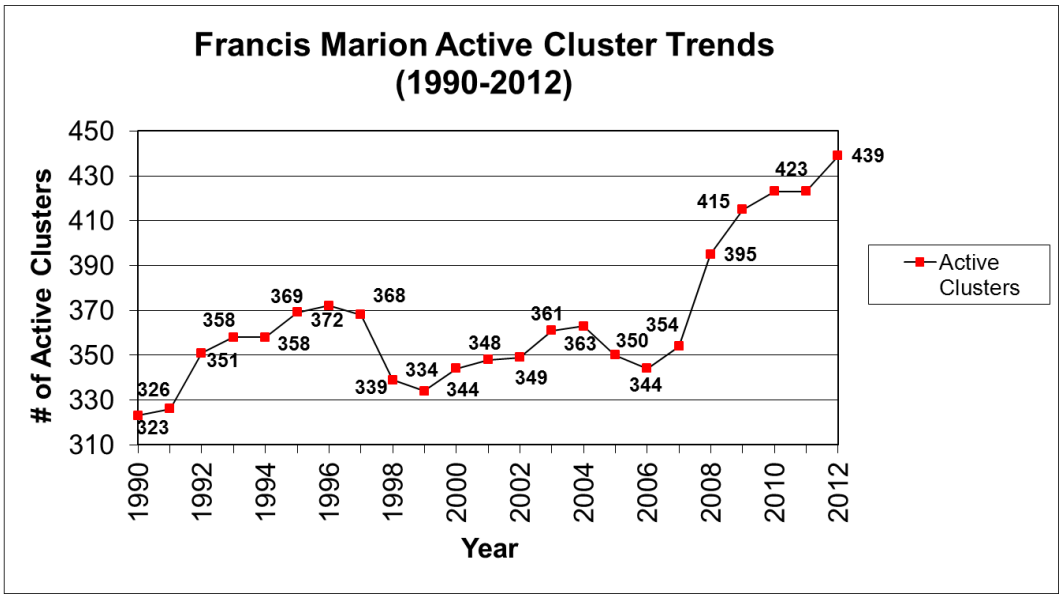

Figure B-1. Active red-cockaded woodpecker cluster trends on FMNF since 1990

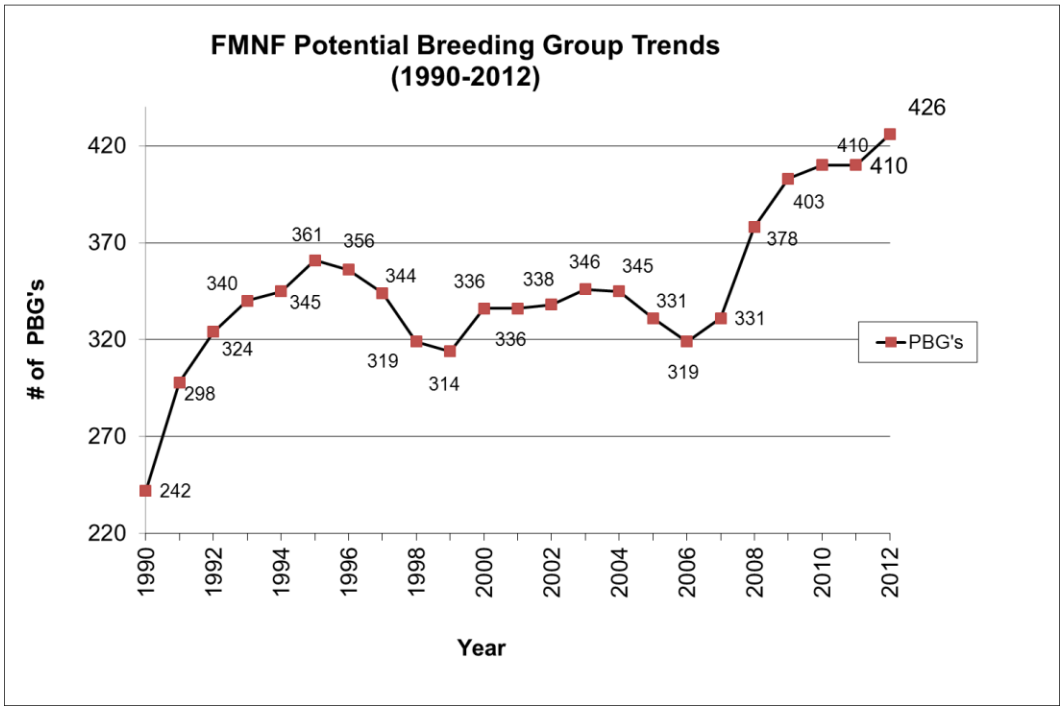

Figure B-2. Potential breed group trends on FMNF since 1990

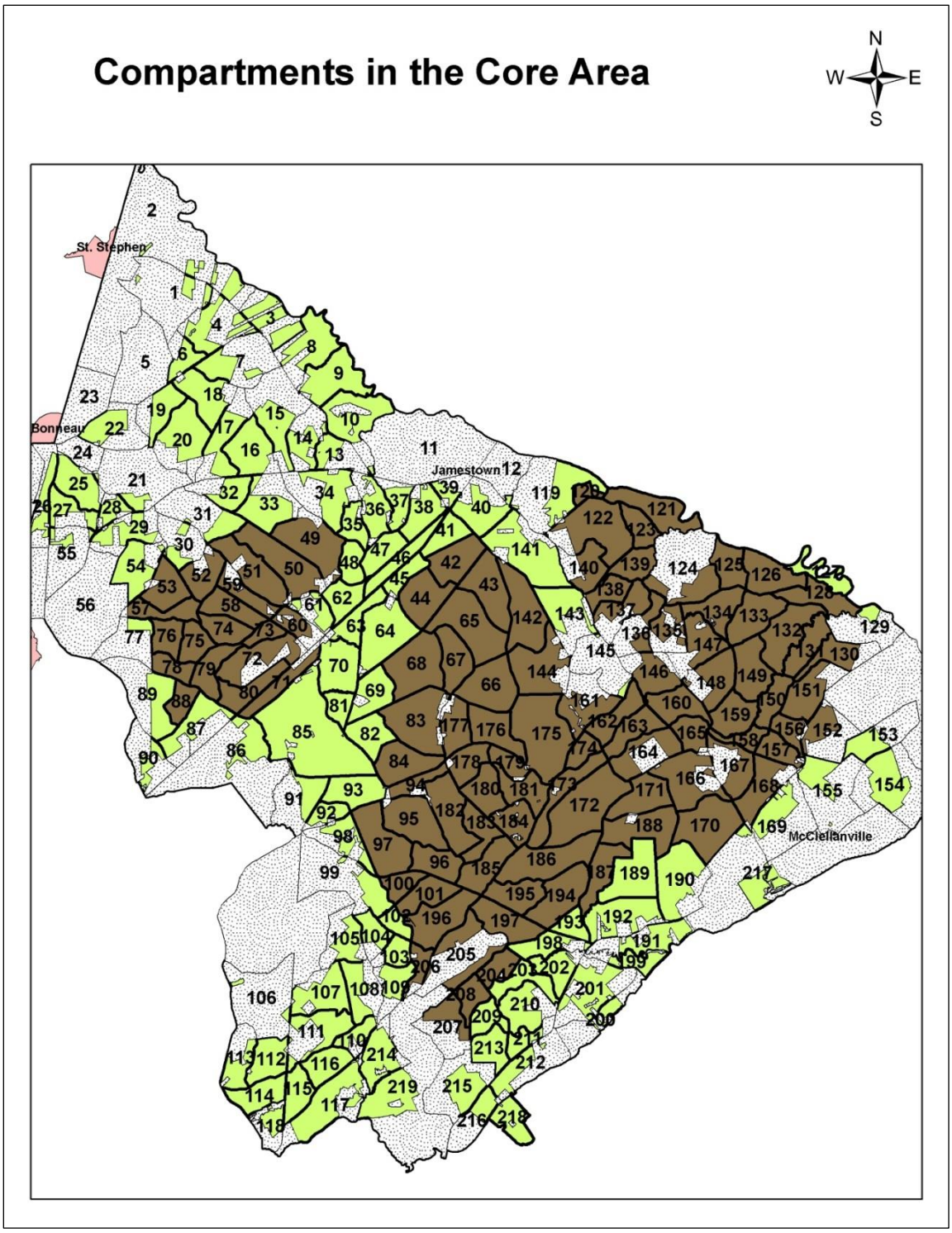

Figure B-3. Core burn area map

Note: Core burn area is in brown. Prescribed burning has and continues to occur outside of the core burn area, but compartments in the core burn area have been consistently burned on a 2 to 3 fire return interval since the 1990s.

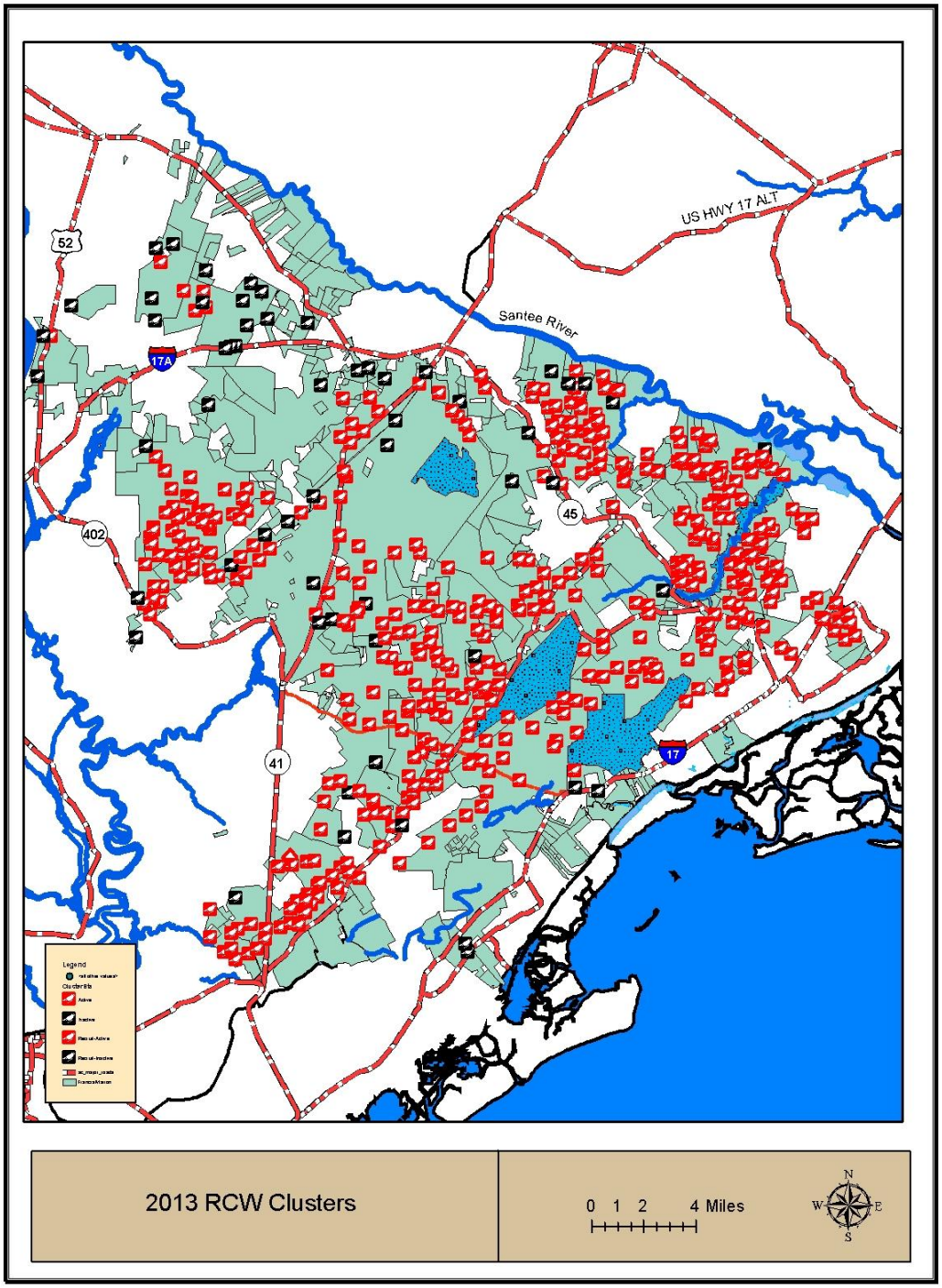

Figure B-4. Active and inactive red-cockaded woodpecker clusters on the FMNF

Note: Black bird symbols represent inactive clusters and red symbols represent active clusters.

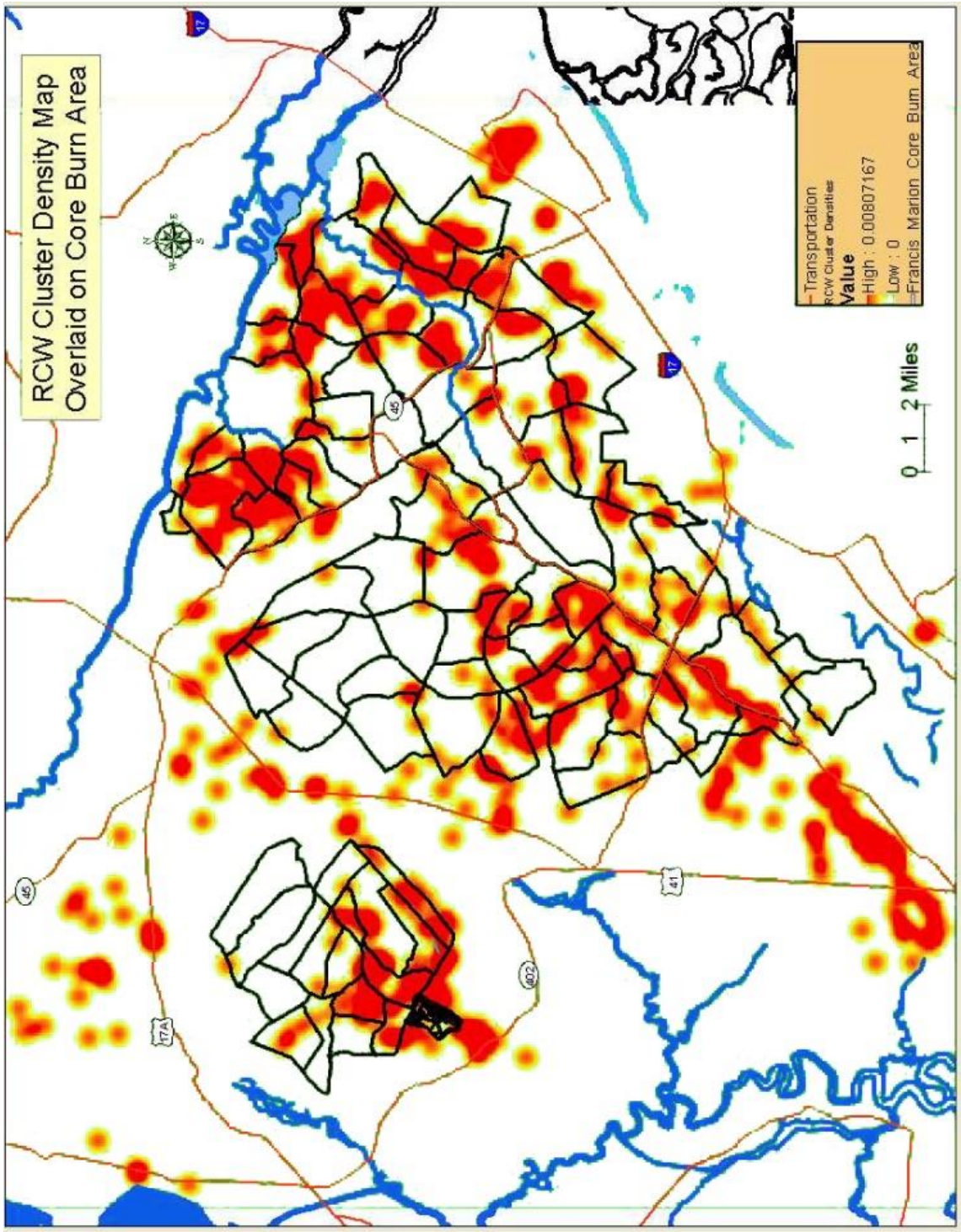

Figure B-5. Red-cockaded woodpecker cluster density overlaid on core burn area compartments

Note: Red represents highest density of clusters, while white represents areas where the clusters are absent. Core burn area compartments are outlined in black.

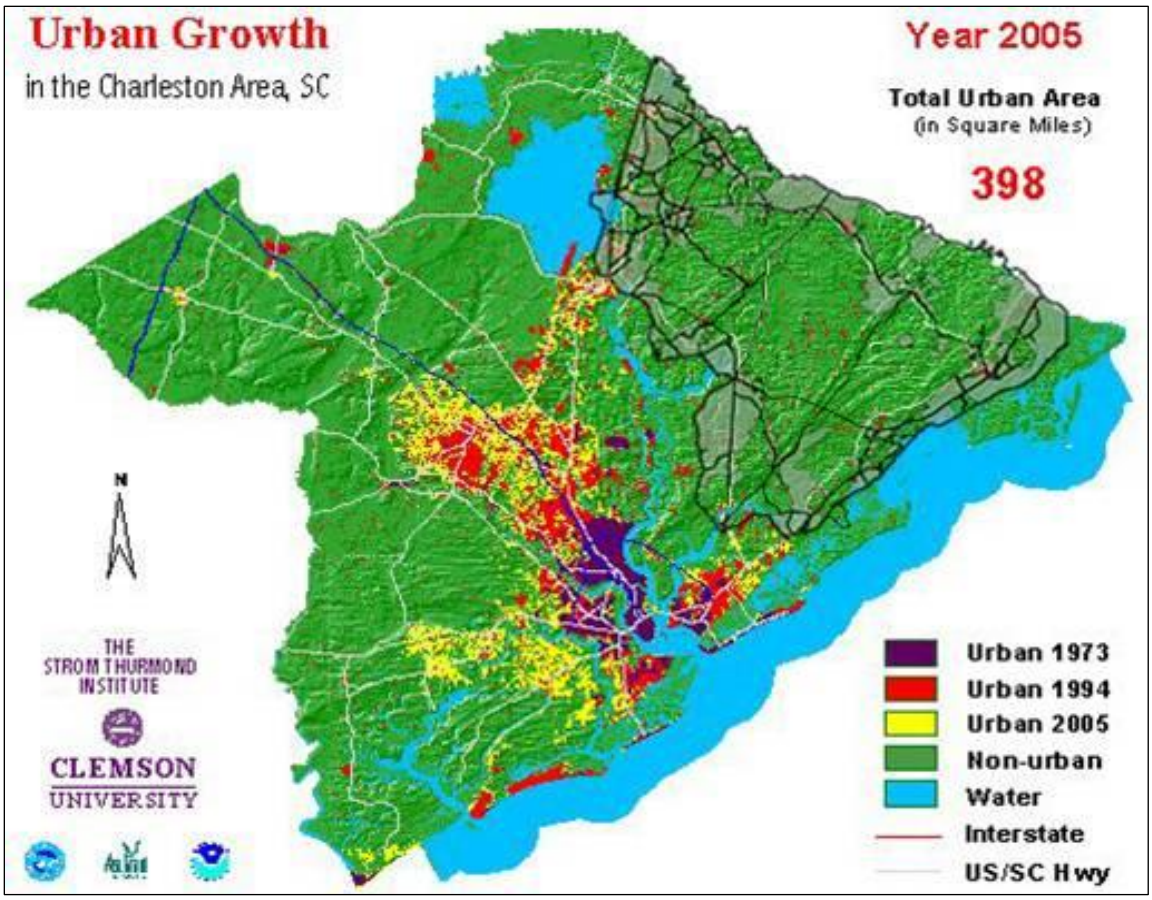

Figure B-6. Map depicting the estimated urban area of Berkeley, Charleston, and Dorchester counties in 2005

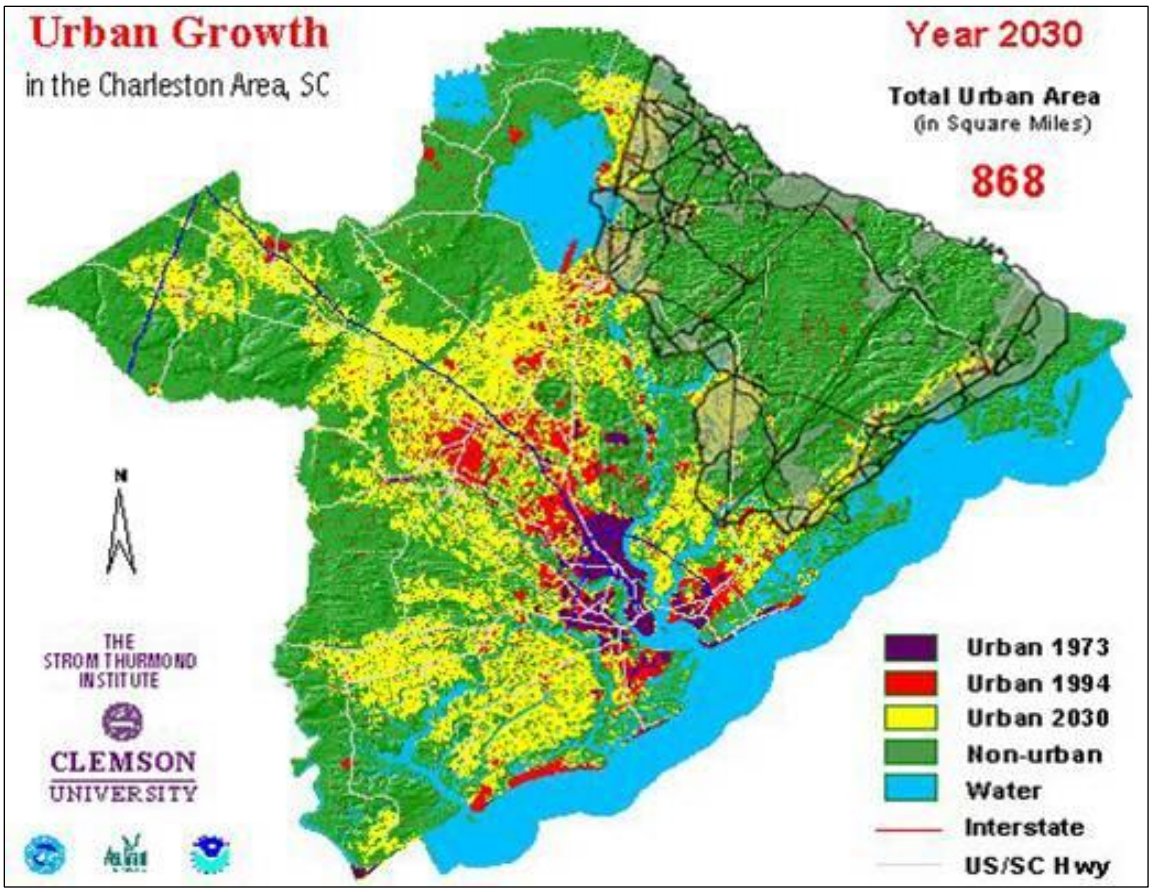

Figure B-7. Map depicting the potential urban area of Berkeley, Charleston, and Dorchester counties in 2030

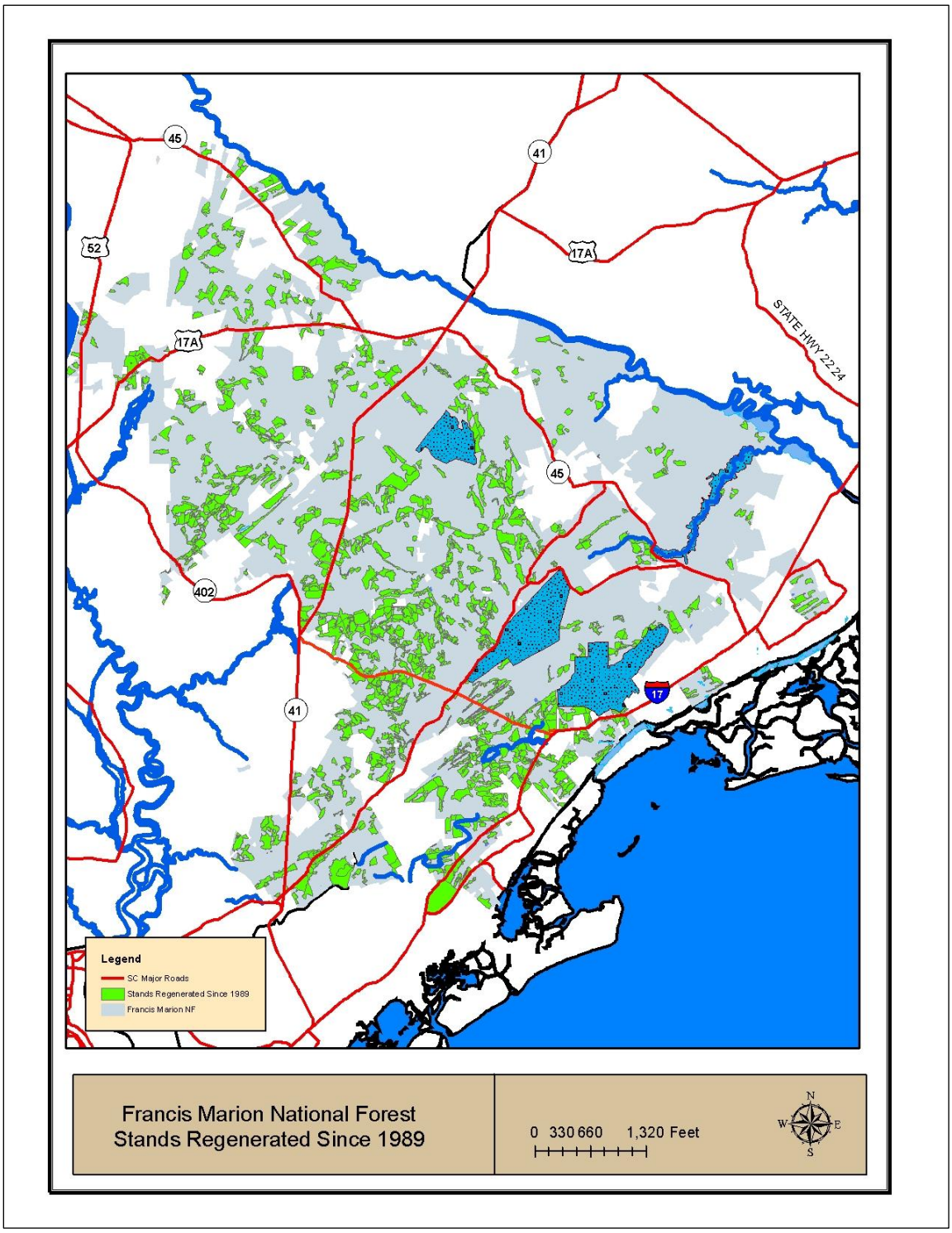

Figure B-8. All stands regenerated on the FMNF since 1989 (approximately 92,000 acres)

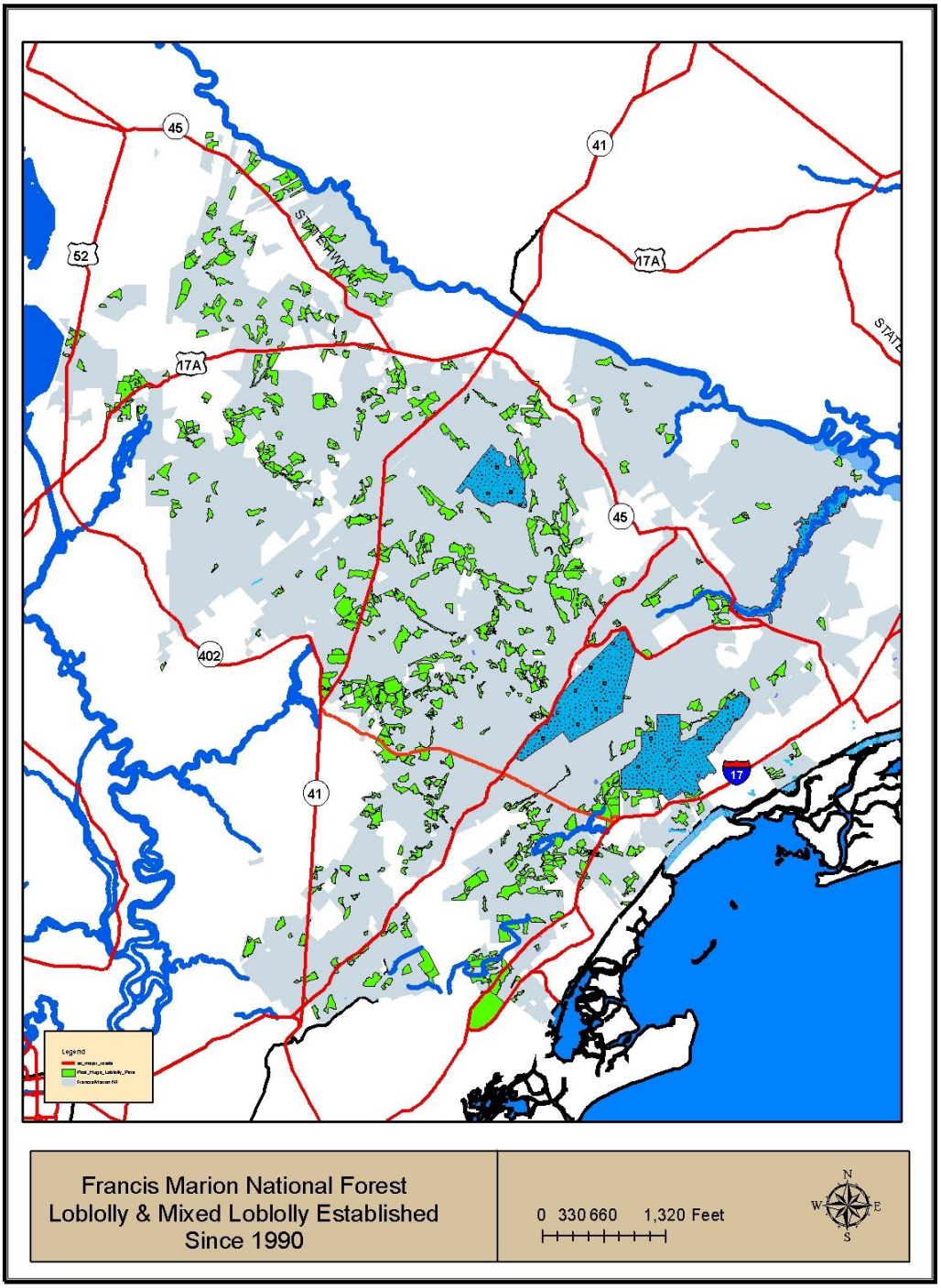

Figure B-9. Loblolly and mixed loblolly established on the FMNF since 1990 (approximately 31,000 acres)

Appendix C: Riparian Areas, Wetlands, Lakes, Streams, Tidal or Freshwater Marsh, Springs, and Seeps

A. Simplified representation of the Riparian – Wetland – Aquatic Systems

Figure C-1 is a simplified representation of the riparian–wetland–aquatic systems to help depict coastal ecosystems.

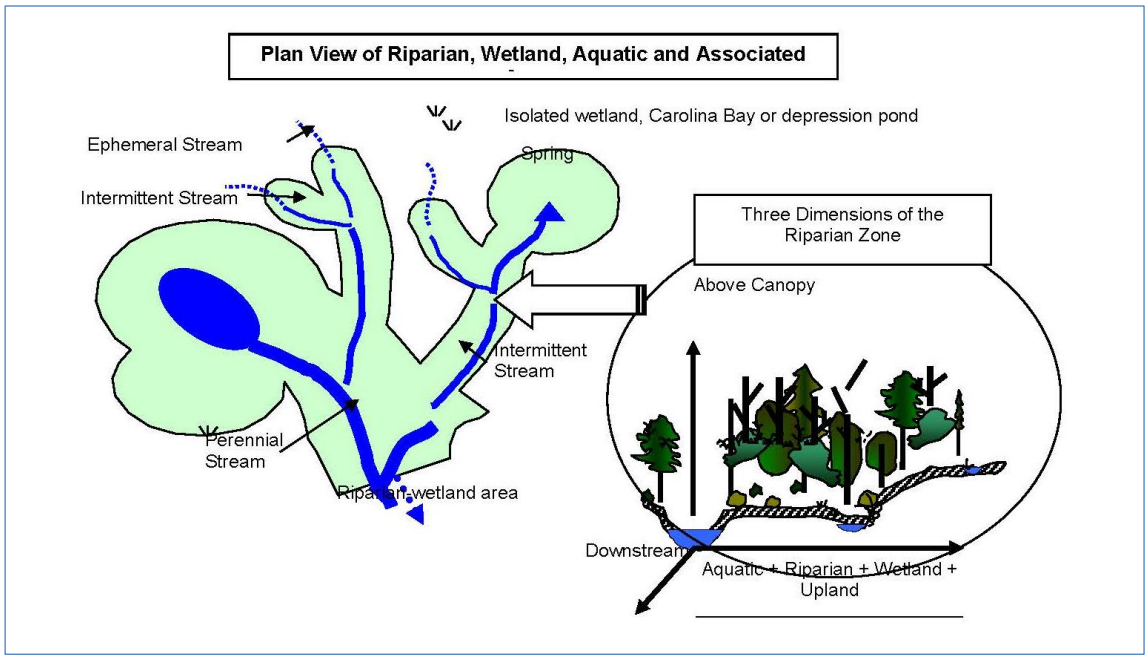

Figure C-1. Simplified representation of the riparian–wetland–aquatic systems

B. Operational Definition for a Riparian Area and Wetlands

Riparian areas are areas associated with freshwater streams, the lotic or flowing aquatic ecosystem. Riparian areas are relatively flat lands with elevated water tables or seasonal flooding that border streams. Wetlands are sometimes confused with riparian areas, and sometimes discussed as if they are the same thing. Under circumstances on the Francis Marion National Forest, both riparian areas and wetlands have hydric soils with poor to very poor drainage. With rare exception, riparian areas on the Francis Marion National Forest are wetlands. This occurs probably because the riverine system has eroded into marine terraces, and being lower than the surrounding, relatively flat terrain, they are fed and accumulate stormflow, interflow and seepage from the adjacent terraces. There are some wetlands that are integrated into aquatic or upland ecosystems that may not be considered as part of the riparian area, but at the landscape planning scale, the aquatic elements are especially difficult to separate. The upland or isolated wetlands are numerous, but tend to be easily seen and identified, unless especially small in size. Riparian-like areas are sometimes found bordering lentic (i.e., non-flowing wetlands, lakes, ponds, tidal flats, etc.), but these areas do not have the flowing water and flooding regime from streams. Tidal and maritime wetlands have varying degrees of salt water influence and plant communities. There is some uncertainty whether tidal streams have riparian areas, because the flooding associated with this is largely driven by the tides as well as a

few other factors such as position of the moon, direction and speed of wind, etc. Distinct types of plant species that occur in riparian areas are often common to wetlands. Some wetland communities may be substantially different from what would be found in a riparian area, but since riparian areas are wetlands, they share many of the same species. Some species do well in just about any wetland ecosystem, while others are better adapted to lotic flowing systems or the lentic (static water) habitats. The plant composition of both riparian areas and wetlands may be associated with the magnitude and duration of flooding, frequency or persistence of saturation from rainfall and groundwater interactions, the type, structure and chemical composition of soils and the types, timing and severity of disturbance as fire, drought, hurricanes, etc.

Riparian areas have variable widths that are typically determined by ecologically significant boundaries rather than arbitrary distances. In areas with more terrain, the stream banks, terraces and other channel features are more defined. The extent of the riparian area can often be estimated by changes in dominant plant species such as bottomland hardwoods to pine when interpreting aerial photos and topographic indicators when reviewing LiDAR hillshade or DEM shading. Their boundaries are most likely to be best determined on the ground by using features of soil, landform and vegetation, and hydrologic indicators when they are present. However, there may be some uncertainty whether some areas are a riparian wetland area, or just a wetland area. Channel features may be lacking and linear depressions become the means by which ephemeral flow passes from upland areas into recognizable streams. Locally, depressions may be able to capture and contain a certain amount of water contributed from adjacent areas. However, water yield averages about 10 inches and eventually an intermittent or perennial stream will typically emerge (Russell, 2013). No feature is used alone to delineate these ecosystems, and the presence of hydrologic modifications can complicate the determinations. Characteristics indicative of these areas include but are not necessarily limited to:

Soils. The physical characteristics of soils that are reflected in their taxonomic names often describe soil properties that are suggestive of riparian status. Soils with rainfall exceeding evapotranspiration, flooding, high moisture holding capacity, moisture restriction and/or elevated water tables within the normal rooting zone reveal these characteristics upon field classification. Soils that map more like linear depressions that have some apparent stream connections are more apt to be considered riparian area wetland, and non-linear depression wetland soils with no connection to streams are isolated wetlands. Uncertainty can develop if there are hydrologic modifications that connect isolated areas to the stream and riparian network. Taxonomic soil names with descriptors such as Fluva (floodprone), Aqua (water) or Ombroaqua (rain and water) are a just few examples. In the instances of the Francis Marion, both wetlands and riparian areas have hydric soils. References include Corps of Engineers Wetland Delineation Manual (Environmental Labatory, 1987), which includes the National List of Hydric Soils . The wetland delineation manual supplement for the Atlantic Coastal Plain adds additional detail to consider (US Corps of Engineers, 2010). NTCHS Field Indicators of Hydric Soils in the United States (USDA Natural Resources Conservation Service 2010) address indicators commonly found in the coastal plain region. Change to NTCHS Field Indicators of Hydric Soils in the United States can be found on the NRCS hydric soils web site (http://soils.usda.gov/use/hydric). Refer to soils section for more information.

Landforms. Riparian areas will include the 100-year floodplain with defined stream banks and poorly defined, linear depressional features. The riverine system has eroded into generally flat, marine terraces (Doar, 2013). The gradients of the channels often support braided or sinuous streams, but what appears as an interrupted stream may be just an especially flat section or a depression that that may have intermittently have some ponding that the stream is flowing

through. The landforms are complex. Lake or pond shores with flooding features may or may not have similar features. Riparian areas typically will have wetland characteristics. Isolated wetlands will often be somewhat unique depressional features such as those described in the preliminary ecological classification as Carolina Bays, typic and deep pond depressions and are not connected to streams or linear depressional features that appear connected (Simon and Heyden, 2013). De Steven and Harrison (2006) addressed many of the differentiating factors of depression wetlands on the Francis Marion National Forest.

Vegetation. The presence, types and abundance of wetland plants are used to help determine wetland and riparian areas. There may be some differences in plant species that tend to be only found in lotic flowing water systems as opposed to lentic wetland or ponded systems. The preliminary ecological classification compiled by Nature Serve for the Francis Marion National Forest (Pyne, M. and C. Nordman, 2012) addresses vegetation, landforms, soils and hydrology. A model as well as site specific delineation of features was developed by Simon and Heyden, 2013 and has been able to differentiate many of these ecological features. References include Corps of Engineers Wetland Delineation Manual (Environmental Laboratory, 1987), which includes a National and Southeast Plant list or other available plant lists on this subject such as the US Fish and Wildlife Service National Plant List of Plants that Occur in Wetlands (Lichvar, R.W. 2012). . The wetland delineation manual supplement for the Atlantic Coastal Plain adds additional detail to consider (US Corps of Engineers, 2010).

Hydrology. Hydrology indicators are not always present or obvious, but can be helpful in determining frequency or likelihood of flooding or flow velocity from adjacent streams. Information and observations pertinent to the situation include drainage area with estimates of streamflow or groundwater levels. Indicators of flooding with water flow include deposits of woody debris along the channel or within or next to trees or other vegetation, buried organic layers within the soil profile, moss, sediment or discolor line on tree trunks, signs of material being sorted or oriented by flow, signs of organic material being removed and floating away. Indicators of extended flooding and water not moving away very quickly would be ponding, buttressed or swollen tree trucks, indicators that surface organic materials accumulate or are slow to decompose from the anerobic conditions. For systems with close ties with groundwater, conductivity of the water will be higher in groundwater fed areas (e.g., 40+ micromhos/cm) as compared to areas dominated by just rainfall or streamflow, but seasonal as well as geologic differences may occur. Drainage size is another potential indicator to consider. Estimates of flow accumulation based on 10 inches of water yield per acre per year and routing of that flow may sometimes be used to suggest amount and/or frequency of flow that may be associated with the drainage size. A 30-40 acre area will typically support a perennial or intermittent stream according to the NC estimates (Russell, 2013). However, there is substantial variability in this figure, and we have seen LiDAR indicators of channels formation on smaller areas and conditions were channel formation is not defined well enough to determine from remote sensing. Based on water yield estimates, a 40 acre area should have on average about 32 acre-feet of water yield, 32 acre-feet of water to evaporate and 96 acre-feet of water to transpire. Unless there is some signs of ponding somewhere in the drainage area, water has to have mechanisms to move from the area. The dense vegetation, roots and other factors help limit the normal defined channel indicators.

Although some of the indicators are technically demanding for classification purposes. Many of the soil, landform, plant and hydrology indicators can be best applied by trained field specialists with interface with remote sensing specialists.

C. Riparian Management Zone

Portions of a watershed where riparian-dependent resources receive primary emphasis, and for which plans include plan components to maintain or restore riparian functions and ecological functions (36 CFR 219.19).

The intent in the planning direction would probably be inclusive in that the riparian management zone(s) would not only address riparian areas and associated conditions such as but also include wetlands, lake shores, tidal marshes, streams, natural ponds, springs, seeps, etc. These areas have soils with attached plants and hydrology. Dividing these into separate categories may be needed at some point to better define the desired conditions and the develop management practices to address them. The 1996 plan did mention many of the basic desired conditions, but then did not follow through sufficiently to address them. The complexity of these systems make it difficult to evaluate their full extent of their three dimension character including vertical above, horizontal or lateral, and depth with groundwater connections. There are some uncertainties in our knowledge as well as ability to compile or reference all pertinent knowledge on these subjects. However, we do know much more now than in previous plans.