

Croatan NF Monitoring Program Administrative Change 05/2/2016

Chapter 5: Monitoring and Evaluation

5.1: Purpose of Monitoring and Evaluation

Monitoring and evaluation are activities that provide information to determine whether programs and projects are meeting forest plan direction, and whether the cost anticipated to implement the plan coincides with actual costs. Direction for the monitoring and evaluation of forest plans is found in FSM 1922.7, FSH 1909.12.6, and 36 CFR 219.12(k).

Monitoring is observing or measuring results for a specific purpose, such as compliance with applicable laws and regulations, or addressing issues. Monitoring measures:

- Progress in forest plan implementation;
- How well the forest plan meets desired conditions, goals, and objectives;
- Whether management standards are appropriate for meeting the forest's outputs and environmental protection; and
- Whether assumptions used in developing the forest plan reflect actual conditions, new information, and/or legal requirements.

Monitoring also increases and improves the level of scientific information available by which to measure the effects of management on sustaining communities and ecosystems.

Forest plan monitoring is required to:

- Quantitatively estimate a comparison of planned versus actual outputs and services;
- Document the measured effects of prescriptions, including significant changes in productivity of the land;
- Document costs associated with carrying out the planned management prescriptions as compared with costs estimated in the forest plan;
- Determine if lands are adequately restocked;
- Determine, at least every ten years, if lands identified as not suited for timber production have become suited;
- Determine if maximum size limits for harvest areas should be continued;
- Ensure that destructive insects and disease organisms do not increase to potentially damaging levels following management activities.

Evaluation of data collected during monitoring assesses the significance of observations or measured results. The assessment of significance is periodically made by managers and interdisciplinary team members, and reported in the annual *Monitoring and Evaluation Report for the National Forests in North Carolina*. Evaluation determines if planned conditions or results are being attained, and if they are within forest plan direction. When a situation is identified as being outside acceptable variability, changes to the forest plan may need to occur. Evaluation, therefore, serves two functions:

- It identifies when a change in management practices is needed; and
- It provides a means to adjust the forest plan to keep it dynamic and responsive to changing conditions.

5.2: Levels of Forest Plan Monitoring

Monitoring the forest plan may occur at three distinct levels. These are:

- Implementation monitoring;
- Effectiveness monitoring; and
- Validation monitoring.

Implementation monitoring is meant to answer the question: *Are proposals being initiated and implemented based on what the forest plan directs?* It determines if plans, prescriptions, projects, and activities are proposed and implemented according to forest plan direction, requirements, and standards. Evaluation of implementation monitoring may require adjustment of prescriptions and targets, or changes in forest plan or project administration (FSM 1922.7).

Effectiveness monitoring is meant to answer the question: *Are management actions moving the forest towards specified desired conditions?* It determines whether plans, prescriptions, projects, and activities are effective in achieving movement toward, or maintenance of, the desired conditions. Evaluation of effectiveness monitoring is used to adjust forest plan objectives, targets, prescriptions, standards, conservation practices, mitigation measures, and other best management practices. Results could lead to a change or amendment to the forest plan (FSM 1922.7).

Validation monitoring is meant to answer the question: *Are assumptions that were used in developing the forest plan valid, or are there better ways to meet the goals and objectives?* This monitoring is designed to ascertain whether the initial assumptions and coefficients used when developing the forest plan are correct. Evaluation can result in amendment of forest plans and may be used to recommend changes in laws, regulations, and policies that affect both the plan and project implementation (FSM 1922.7).

5.3: The Monitoring Plan: Five Categories of Questions

The monitoring plan consists of monitoring questions, items to be measured (actions, resources or effects), the frequency of measurement, and the responsibility for reporting. Monitoring questions were developed based on the revised forest plan objectives, goals, and standards. Baseline data and information are provided in Section 5.4 of this chapter. Monitoring questions help to determine whether the revised forest plan decisions are being implemented, and whether the decisions are effective and valid. Tasks for the monitoring program, which provide more detail about answering monitoring questions, will reside on the website and be updated biennially.

The monitoring plan is organized into five categories of questions. Each monitoring question addresses a group of goals, objectives, or standards. There are 2 parts to each category: a) questions referring to desired outcomes (validation or effectiveness), and b) questions about the rate of implementation of goals and objectives that likely contribute toward achieving desired outcomes.

Available baseline data will be used to compare changes in the future resulting from management actions and other natural processes. Coordinating efforts with existing resource inventories may minimize duplication in data collection and reporting (FSM 1922.71). The items that will be measured and the frequency of collection, capture what will be used to incrementally monitor success, failure or some degree of either, and the duration between data collection.

The monitoring questions are organized into the following major topics:

- Ecosystem or watershed restoration
- Habitats least affected by management activities;
- Public use and customer satisfaction;
- Sustaining local communities; and
- Project implementation.

2016 Update

The monitoring program was updated in 2016 to meet the requirements of the 2012 Planning Rule monitoring transition. The reporting frequencies for the monitoring program have been updated using multiples of 2-year periods. The 2012 Planning Regulations changed the reporting frequency from an annual to biennial evaluation of monitoring results.

Some questions in the updated Plan Monitoring Program link to a broad scale monitoring strategy. The 2012 Planning Regulations require a broad scale monitoring strategy, in addition to the plan level monitoring program. The Regional Office is responsible for the broad scale strategy, which is under development as of March 2016. The purposes of the broad scale strategy are to address:

- Monitoring needs most efficiently addressed for multiple plan areas at the same time or are beyond the technical feasibility of a single plan area
- Contribute to a broader understanding of the landscape surrounding national forests
- Provide information necessary to evaluate plan implementation

Questions and indicators that cite the broad scale strategy can be reviewed on the regional website: www.fs.usda.gov/main/r8/landmanagement/planning.

5.3.1 Monitoring Questions

5.3.1.1. Monitor Select Ecosystems and Watersheds.

Question: 1a) What are the conditions of selected ecosystems or watersheds and their key characteristics on the CNF? How do they compare with planned goals? 1b) Of the goals and objectives that likely contribute toward or affect the ecological conditions, what are the rates of implementation?

The primary direction of the CNF Plan is restoring biological diversity . Biological diversity is provided by using a coarse filter/fine filter approach to managing ecosystems, watersheds, and plant and animal diversity.

5.3.1.2. Monitor Habitats Least Affected by Management Activities

Question: 2a) On landtypes where planned management actions are relatively infrequent and low

impact, what are the habitat conditions? Are plan objectives being met? 2b) Of goals and objectives likely to contribute towards the conditions of these habitats, what are the rates of implementation?

The CNF Plan proposes active management in predominantly 5 ecological landtypes (Ecological Classification System, Appendix A). Within these landtypes and associated management prescriptions, focal species are monitored to assess the function of the ecosystem. The remaining 3 landtypes either have no management activities proposed that alter habitat, or the management activities are limited in amount and distribution to only have minor localized effects. The change in habitat for these landtypes will be monitored.

The landtypes that will be monitored are lake and stream swamps, tidal streams and estuaries, and maritime ridges and dunes. These landtypes were allocated to the hardwood cypress wetland and pocosin lake management prescriptions.

5.3.1.3. Monitor Public Use and Consumer Satisfaction.

Question: 3a) What amount and kinds of public use activities are occurring on the CNF and how satisfied are people with their experiences? 3b) Of goals and objectives that would contribute toward the trends of public use and satisfaction, what is the rate of implementation?

In 1998 a recreation sampling system was developed by research and forest staff that would be cost effective and provide reliable recreation use information at the forest, regional, and national level. The National Visitor Use Monitoring (NVUM) project is the permanent sampling protocol that was developed. It was implemented nationally to gauge the importance of, and satisfaction with, recreational opportunities within the national forest system. The NVUM is administered once every four years on every national forest in the country. The National Forests in North Carolina participated in the NVUM project from October 2000 through September 2001. The results collected are applicable only at the NFsNC level, and not intended to be accurate at the district or site level (NVUM Report June 2002). The sampling results can therefore not be applied specifically to the Croatan National Forest. To answer what and how much people are visiting the Croatan National Forest, and to what extent they are enjoying the experience, a survey specific to the CNF is needed.

Using the sampling protocol as the NVUM utilized, information will be collected for the Croatan National Forest sometime between 2002 and 2006, when the next scheduled sampling will occur for all the National Forests in North Carolina. Questions that pertain specifically to the CNF will be developed to focus the results on answering the monitoring question. The preliminary sample design, sampling unit selection, sample size and variability, and survey implementation must be developed in coordination with District, Forest and Research input.

5.3.1.4. Monitor Local Community Needs and Community Actions

Question: 4a) Are local communities attaching special significance to the natural and cultural attributes of the CNF as contributing to their well-being, and if so, how is this attachment exhibited through community actions? 4b) Of goals and objectives that would contribute toward creating a sense of place for local communities, what are the rates of implementation?

People can form a strong bond of attachment to the land, the people in their community, and their

culture. This attachment has been called a sense of place. Communities with strong attachment to a place can articulate what special attributes contribute to their perception of well-being. These communities tend to take special precautions to preserve those attributes. The CNF has many natural and cultural attributes that may contribute toward a positive sense of place. To recognize this area as a special place, a collaborative effort among federal and state agencies with local communities and governments is needed.

5.3.1.5. Design and Implementation of Projects

Question: 5a) Are projects being designed to achieve desired conditions of the management prescriptions? 5b) Are projects being implemented according to decisions made through the NEPA process, including plan standards?

The Forest Service currently has multiple methods of reporting accomplishments every year. Each program area tracks projects that are initiated, ongoing, or implemented during the fiscal year. In addition, reviews of programs are conducted yearly that monitor project implementation and whether the projects are according to Forest Plan direction, including Plan standards such as the requirement to follow NC Best Management Practices for Forestry, and the NC Forest Practice Guidelines Related to Water Quality. Regional and Washington Office reviews as well as Forest-wide reviews take place periodically as an overall assessment of the direction in which resource management is headed.

5.3.1 Monitoring Questions and Indicators

The following table displays the monitoring questions and the goals, objectives and indicators associated with addressing the question.

Table 5.3.1 Monitoring Questions and Indicators (updated 02/20/2016)

Question Category	Question	Indicator	Goal/ Desired Condition/ Objective	Frequency
(i) The status of select watershed conditions				
1a. What are the conditions of selected ecosystems or watersheds and their key characteristics?	Q1. Are aquatic habitat and biota conditions of tidal and non-tidal streams progressing toward desired conditions?	<p>% streams in the following condition classes: 1) functioning properly, 2) functioning at risk, functionally impaired.</p> <p>Key characteristics:</p> <ul style="list-style-type: none"> • Aquatic passage • Large wood • Water quality: ph, dissolved oxygen, salinity • Presence of native fish community 	<p>Goal/DC: 2.1.8</p> <p>Objectives: 2.2.8 #'s 1,4,5)</p>	4-year
(ii) The status of select ecological conditions including key characteristics of terrestrial and aquatic ecosystems				
Category 1a.	Q2. Are pine savannas, pine flatwoods, and woodlands improving toward desired conditions?	<p>Determine condition classes: 1) Maintain, 2) Improve, 3) Restore</p> <p>Key Characteristics:</p> <ul style="list-style-type: none"> • Pine Canopy with open canopy condition • Large diameter trees distributed throughout • Understory of small shrubs and bunchgrasses 	<p>Goal/DC: 2.1.1</p> <p>Objectives: 2.1.1 #s6,7</p> <p>Goal/DC: 2.4.1a</p> <p>Objectives 2.4.1 #s 1,2</p>	4 year
2a. On landtypes where planned management actions are relatively infrequent and low impact, what are the	Q3. Are hardwood cypress wetlands maintained and functioning as planned?	<p>Determine condition class 1) Maintain, 2) Improve, 3) Restore</p> <p>Key Characteristics:</p> <ul style="list-style-type: none"> • Composition dominated with wet hardwoods and cypress 	<p>Goal/DC: 2.1.6</p> <p>Objective: 2.1.6.1</p>	4-year

Question Category	Question	Indicator	Goal/ Desired Condition/ Objective	Frequency
habitat conditions?		<ul style="list-style-type: none"> Depth of water table Stringers functioning as connectors with large and small patches Low open road density 		
Category 1a.	Q4. Are upland hardwood conditions maintained or improving?	Condition classes of upland hardwoods Key Characteristics: <ul style="list-style-type: none"> Hardwood canopy Presence of hard and soft mast 	Goal/DC: 2.1.7 Objectives: 2.1.7 #s 1,2	4-year
(iii) The status of focal species to assess ecological conditions under 36CFR 219.9				
Categories 1a and 2a.	Q5. What is the status of Red Cockaded Woodpecker to assess the ecosystem functioning of pine savannas, flatwoods, and woodlands?	Active clusters Potential breeding pairs	Goal/DC: 2.1.1	2-year
	Q6. What is the status of black bear to assess ecosystem function and connectivity of hardwood cypress wetlands?	Harvest trends Mortality data	Goal/DC: 2.1.5a)	2-year
	Q7. What is the status of eastern wild turkey to assess the function of upland hardwoods	Harvest trends Summer brood counts	Goal/DC: 2.1.7	2-year

Question Category	Question	Indicator	Goal/ Desired Condition/ Objective	Frequency
	Q8. What is the status of longleaf pine and wiregrass to assess the function of longleaf pine ecosystems?	Longleaf pine ecosystem condition classes as specified in Question 2 (above)		4-year
(iv) The status of a select set of ecological condition required under 36 CFR 219.9 to contribute to the recovery of federally listed threatened or endangered species, conserve proposed and candidate species, and maintain a viable population of species of conservation concern.				
Category Questions 1a and 2a.	Q9. What are the conditions of special interest natural areas on the CNF?	Condition of each natural area to continue supporting rare species	Goal/DC: 2.1.2-2/1/3 Objectives: 2.1.3.1 and 2.1.3.3	2-year
Categories 1a & 2a.	Q10. What are the occurrences of specific at risk plant species?	Occurrences of the following: <ul style="list-style-type: none"> • Rough leaved loosestrife • Carolina goldenrod • Mimic glass lizard • Spring flowering 	Goal/DC: 2.1.2-2/1/3 Objectives: 2.1.3.1 and 2.1.3.3	2-year
Categories 1a & 2a.	Q11. What are the amounts and conditions old growth in each ecological type	Acres of old growth in each ecological type	Goal/DC: 2.1.4	2-year
Category 2a.	Q12. What is the status of rare landtypes in the plan area?	Amount and condition of each of the following landtypes: <ul style="list-style-type: none"> • Canebrake • Marsh • Maritime Forest • Atlantic White Cedar 	Goal/DC: 2.1.3.a & b)	4-year
(v) The status of visitor use, visitor satisfaction, and progress toward meeting recreation objectives				
3a. What amount and	Q13. What amount and	NVUM survey	Goal/DC: 2.1.4	6-year

Question Category	Question	Indicator	Goal/ Desired Condition/ Objective	Frequency
kinds of public use activities are occurring on the CNF and how satisfied are people with their experiences?	kinds of public use activities are occurring on the CNF and how satisfied are people with their experiences?	(National Visitor Use Monitoring program)		
Category 3a.	Q14. What are the changes in conditions of ROS settings	Change in ROS settings	Goal/DC: 2.1.3.a&b)	4-year
(vi) Measureable changes on the plan area related to climate change and other stressors that may be affecting the plan area				
	Q15. How has climate variability changed and how is it projected to change across the region?	This question will be addressed through the R8 Broad Scale Monitoring Strategy		
	Q16. How is climate variability and change influencing the ecological, social, and economic conditions and contributions provided by plan areas in the region?	This question will be addressed through the R8 Broad Scale Monitoring Strategy		
	Q17. What effects do national forests in the region have on a changing climate?	This question will be addressed through the R8 Broad Scale Monitoring Strategy		
	Q18. Are land	Extent of land cover		

Question Category	Question	Indicator	Goal/ Desired Condition/ Objective	Frequency
	cover changes occurring due to sea level rise, especially lands adjacent to tidal streams?	change by water.		
(vii-a) Progress toward meeting the desired conditions and objectives in the plan, including providing for multiple use opportunities				
Category 3a.	Q19. What is the status and conditions of Wilderness areas on the CNF?	Change Wilderness conditions <ul style="list-style-type: none"> • ROS settings • Fuel loadings 	Goal/DC: 2.3.1 a-d)	4-year
	Q20. What is the status of eligible Wild and Scenic rivers on the CNF?	Wild and Scenic river assessments <ul style="list-style-type: none"> • Change in ROS settings 	Goal/DC: 2.3.2	4-year
	Q21. What is the status and condition of the transportation system?	<ul style="list-style-type: none"> • Open roads • Seasonally open roads • Closed roads 	Goal/DC: 2.6.1 (a-c) Objectives; 2.6.1 #s 1-3	4 year
Categories 1b,2b,3b,4b &5	Q22. What are the rates of implementation in achieving desired conditions and objectives?	Compare the actual condition assessments in this monitoring table with planned outcomes		2-year
(vii-b) Social, economic, and cultural sustainability must also be addressed in the monitoring program				
4a) Are local communities attaching special significance to the natural and cultural attributes of the CNF as contributing to their well-	Q23. Are local communities attaching special significance to the natural and cultural attributes of the CNF as contributing to their well-being, and if so, how is	Number of action plans collaborated with local communities Number of special events sponsored through collaborative efforts	Goal/DC: 2.7.3 (a-b)	2-year

Question Category	Question	Indicator	Goal/ Desired Condition/ Objective	Frequency
being, and if so, how is this attachment exhibited through community actions?	this attachment exhibited through community actions?			
Category 4a	Q24. What are the conditions of cultural and historic Special Interest Areas?	Changes in cultural/historic site conditions: monitored, stabilized, investigated, interpreted, and protected from vandalism	Goal/DC: 2.7.3c Objective: 2.7.3.3	2-year
Category 4a	Q25. What are the risks of wildfire that may affect local communities and what strategies may provide for community protection from wildfire?	Projects implemented through Community Wildfire Protection Plans	Goal/DC: 2.7.3d and 2.5.1a Objective: 2.7.3.5 and 2.5.11.3	2-year
	Q26. What changes are occurring in the social, cultural, and economic conditions in the areas influenced by national forests in the region?	This question will be addressed through the R8 Broad Scale Monitoring Strategy		
(vii) The effects of each management system to determine that they do not substantially and permanently impair the productivity of the land (16 USC 1604(g)(3)(C))				
Categories 1a and 2a.	Q27. Are there any impairments to soil productivity occurring? And if so, what are	BMP monitoring	Legal requirement	2-year

Question Category	Question	Indicator	Goal/ Desired Condition/ Objective	Frequency
	the restoration strategies			

5.4 Background Information for Monitoring

5.4.1 Baseline data for Monitoring Focal Species

RCW

Population Monitoring: The RCW monitoring program on CNF exceeds the requirements set forth in the USDA Forest Service's Final Environmental Impact Statement (1995, FEIS) for RCW on national forest lands in the Southern Region but is consistent with U.S. Fish and Wildlife Service's Revised Recovery Plan for RCW (2000, Draft). The Recovery Plan suggests Level IV monitoring for populations deemed essential to recovery and occurring on public lands. Level IV monitoring consists of color-banding nestling and adult birds, conducting nest checks at 7-11 day intervals, and conducting fledgling and adult checks to determine number and sex of birds. Level IV monitoring may be conducted on a sample of active clusters (IVa) or on all active clusters (IVb) as has been done on CNF for the past 10 years.

The RCW FEIS requires that all clusters be surveyed annually for activity status and that only a sample of clusters be monitored annually for nesting success and group composition. However, the Recovery Plan states that monitoring methods should not be mixed from year to year and that color-banding birds will be necessary when and if translocations are used as a management tool. Furthermore, the Recovery Plan states that due to sampling error, "...intensive monitoring of a sample of groups (Level IVa) can provide reliable estimates of productivity within a short period, but cannot estimate population trend until used for a longer period of time (e.g., 5 years)" and that "Accuracy of population trend assessment is also dependent on sample size... Thus, small samples cannot detect anything but large-scale changes in populations trends." Therefore, continued use of Level IVb monitoring on CNF will provide consistency and the most accurate population information. However, should the CNF population become too large for Forest Service staff to conduct 100% population monitoring, then statistically sound sampling methods can be implemented to monitor a subset of the population.

Population Dynamics: Several variables are important for monitoring population dynamics including number of active clusters, number of potential breeding pairs, proportion of solitary males, and average group size. An active cluster is defined as one that has evidence of RCW

activity including presence of active sap wells, fresh wood chips in one or more cavities, and birds observed in the vicinity of the cavity trees. A potential breeding pair is defined as a male and female pair of adult RCWs residing in an active cluster. Both are measures of population size, indicating number of potential RCW groups and size of the breeding population, respectively.

In general, the number of both active clusters and potential breeding pairs began to increase in 1991 following implementation of Walters management plan (Table 5.2). These numbers continued to increase each year from 2 % to 8 % peaking in 1996. The population subsequently suffered a net loss of activity at two clusters per year (3 %) from 1997 through 1999. However, the population experienced a 6.5 % increase from 1999 to 2000 that included the formation of two entirely new clusters. One of the new clusters was artificially created and the other was a result of territorial budding. The number of active clusters remained the same from 2000 to 2001. However, one recruitment cluster was occupied by a solitary bird post-breeding season. This cluster will not be considered active unless it remains active through the 2002 breeding season. The CNF breeding population experienced a net increase of one breeding pair in 2001.

The CNF has been within the normal range of reproductive values (Table 5.3). The proportion of groups that did not attempt a nest has, for the most part, remained below 10%. Annual mean clutch size has been around 3 eggs per nest (range 2.98 – 3.48), and the mean number of young produced has been around 1.5 per group (range 1.31 – 1.83). Furthermore, partial brood reduction has primarily remained at or below the average of 40% loss.

Analysis indicates that CNF currently supports a viable population of RCWs. The viability of this population is dependent upon the continued use of prescribed burning within RCW territories to control hardwoods and promote an understory of native grasses and forbs. It is also dependent upon maintaining an adequate number of suitable cavities for roosting and nesting.

Table 5.2. Population parameters, 1990-2001

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Active Clusters	44	50	53	54	57	59	64	62	60	58	62	62
Potential Breeding Pairs	36	43	47	49	52	53	55	50	48	45	52	53
% Solitary Males	9.1	8.0	9.4	3.7	5.3	8.5	9.4	12.9	10.0	6.9	9.7	9.8
Avg. Group Size	2.69	2.44	2.53	2.55	2.58	2.64	2.47	2.42	2.31	2.36	2.54	2.62
# Adults	111	125	133	135	151	165	158	139	137	121	142	144

The data indicates that the RCW population trend on the Croatan National Forest is increasing. After reaching a peak in 1996, the Croatan National Forest experienced a slight decline in numbers of active clusters and potential breeding pairs. The decline reversed in 2000, and the population trend continues to increase. Forest plan monitoring will continue over the next 10 years.

Plan expectations: By implementing the Plan it is expected that the number of new RCW clusters would increase by 2-3 each year. However, if the trend changes and the number of clusters begin to decrease and/or new clusters do not get established, the causal factors will be investigated and a plan amendment may be triggered.

Table 5.3. Reproductive parameters, 1990-2001

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Potential Breeding Pairs	36	43	47	49	52	53	55	50	48	45	52	53
% no nest	8	7	9	16	12	9	9	8	8	2	4	15
Clutch size	3.43	3.47	2.96	3.14	3.20	3.07	3.16	3.11	3.16	3.20	3.27	3.20
% fail	21	12.5	21	29	26	21	20	32.6	13.6	13.6	14	6.6
% renest	29	60	22	25	41.6	60	60	67	16.6	16.6	28.6	0
% Partial Brood loss	40	41	37	33	28	40	38	35	44	38	36	41
Brood size	2.06	1.98	1.78	1.82	1.96	1.81	1.86	1.73	1.73	1.98	2.06	1.85
Fledglings	52	72	62	64	84	76	85	74	63	78	95	79
Young/group	1.49	1.67	1.38	1.45	1.65	1.41	1.52	1.32	1.40	1.73	1.83	1.72

Longleaf/Wiregrass

The change in longleaf pine forest abundance, structure, and composition will be used to evaluate and adjust restoration and maintenance activities in these ecosystems on the CNF. The current abundance of longleaf pine forests was determined from the Continuous Inventory of Stand Condition (CISC) database. Periodic updates of this data base following field inventories will be used to determine the change in longleaf pine forest abundance on the CNF during Plan implementation.

The structure and composition of understory plants was measured at permanent monitoring plots from a random sample of pine stands in 2001. Plot data has been entered into a database. Additional permanent monitoring plots will be installed yearly, and measurements will be added to the existing database. Several plots will be established in areas that have pine straw harvesting proposed. A portion of the monitoring plots will be repeated at approximately 3-year intervals. The change in understory structure and composition in longleaf pine stands during plan implementation can be determined by evaluating data from repeated sampling.

Population Dynamics: Current abundance, structure, and composition in pine stands on the CNF are summarized in Tables 5.4a and 5.4b for land within and outside the RCW HMA and within and outside areas currently managed using prescribed fire (burn units). The data are stratified into these categories to facilitate comparison between areas having different management objectives and possibly different management intensities and results. These data are also available summarized by ecological type (potential natural vegetation, soil drainage, and soil texture). The data are stratified into these categories because inherent site capabilities and limitations strongly influence management outcomes. Evaluating the change in longleaf pine

forest abundance, structure, and composition within ecological types will allow managers to fine tune management activities to better-fit site capabilities found on the CNF.

The data available for longleaf indicate that a large amount of acreage exists with potential for restoration to longleaf pine. A small portion of this acreage is currently outside of prescribed burning units, which indicates restoration to longleaf may be more difficult due to the inability to apply fire. The data available for wiregrass indicate that the areas within burn units and the RCW HMA have a higher percent of wiregrass than areas not in burn units. The occurrence of small shrubs in conjunction with wiregrass is an interesting indicator that will be examined more closely with additional monitoring plots and repeated sampling.

Plan expectations: The number of acres of longleaf should increase. In conjunction with the number of acres of longleaf pine increasing, the percent of wiregrass within the RCW HMA should also increase due to lower impact restoration techniques and increased prescribed fire. The percent cover of small shrubs, tall shrubs and cane should decrease with more application of fire. However, the sites with higher percent cover of species other than wiregrass is thought to be due to soil type, and not necessarily directly related to the amount of prescribed fire applied to the area.

Table 5.4a: Current and potential longleaf pine forests (acres) within and outside the RCW Habitat Management Area (HMA) on the CNF.

Vegetation Type	Within RCW HMA			Not In RCW HMA
	Territories with Active Clusters	Territories with Recruitment Clusters	Not Currently in Burn unit	Not Currently in Burn unit
Longleaf pine Forests ¹	5,108	5,806	1,364	352
Longleaf pine potential	3,267	9,205	3,580	604

¹from Continuous Inventory of Stand Condition (CISC) data base (does not include 263 acres of longleaf pine not in RCW HMA but within a burn unit)

Table 5.4b: Number of samples (n), average cover percent, and (95% confidence range) for understory and midstory plants from a random sample of pine stands within and outside the RCW Habitat Management Area (HMA) on the CNF in 2001.

Vegetation Strata	Within RCW HMA			Not In RCW HMA
	Territories with Active Clusters	Territories with Recruitment Clusters	Not Currently in Burn unit	Not Currently in Burn unit
sample size	23	24	4	4
Wiregrass	16 (10-21)	8 (3-13)	2 (0-5)	1 (0-1)
Small shrubs ¹	41 (32-51)	31 (23-38)	36 (23-50)	58 (54-61)
Tall shrubs ²	7 (3-10)	13 (7-19)	30 (11-60)	45 (10-79)
Cane+ ³	5 (2-9)	4 (2-7)	16 (0-44)	1 (0-1)

¹ small shrubs are ≤ 1.5 meters in height

² tall shrubs are > 1.5 meters in height

³ giant cane and other grasses

Wild Turkey

The North Carolina Wildlife Resources Commission tracts wild turkey populations annually. Using data collected by NCWRC, the Forest Service can use the information to estimate trends in response to active management. Wild turkey populations are divided into regions – Mountain, Piedmont and Coastal. Observational data, summer brood surveys, and harvest reports provide information in regard to population status by area and for the State. Wild turkey observations made by Commission personnel and/or other cooperators were recorded and tabulated statewide. Cooperators statewide conducted the 2000 wild turkey summer brood survey. Summer brood surveys are conducted each year during July and August. This information provides a wild turkey productivity index for the various regions of the State.

Table 5.5 Historical Summer Brood Survey Results, 1988-2000

Year	Total Turkeys Observed	Average Poult/Hen Ratios			
		Coast	Piedmont	Mountain	State
1988	662	3.5	2.6	6.2	5.5
1989	1,486	2.1	4.2	4.1	3.5
1990	1,259	2.8	4.9	3.2	3.6
1991	2,021	3.6	5.1	4.8	4.3
1992	1,218	2.7	1.5	1.8	2.0
1993	2,485	4.0	3.5	4.6	4.2
1994	3,473	2.8	3.8	3.3	3.3
1995	4,259	3.6	2.9	2.4	2.6
1996	5,418	3.0	3.3	2.4	2.7
1997	5,746	3.0	2.6	1.6	2.1
1998	9,289	2.8	3.7	3.5	3.5
1999	8,450	3.1	3.0	2.5	2.7
2000	11,599	3.2	3.1	2.8	3.0

Population Dynamics: Wild turkey productivity varied only slightly between geographical regions (Table 5.5). All three geographical regions experienced good nesting success (70%, 69%, and 73% of the hens were with poults in the coastal, piedmont, and mountain regions respectively). The coastal and piedmont regions experienced good poult survival (both with 4.6 poults/brood) and very good overall productivity (3.2 and 3.1 poults/hen respectively). The wild turkey population in the State is currently on an upward trend. This can be measured in several ways, particularly in harvest. Table 5.6 depicts the statewide historical wild turkey harvest for 1991-2001. Populations and harvests in the Coastal Region are steadily increasing. Intensified restoration efforts in this region in recent years should accelerate both population growth and harvest increases in the future.

Plan expectations: By implementing the Plan it is expected that the trend in the wild turkey population should continue to increase due to restoring upland hardwoods and protecting hardwood cypress wetlands. However, it is important to note that wild turkey habitat provided on the Croatan National Forest is only a portion of the overall habitat provided in the coastal area that supports the population. Activities such as hunting seasons, number of hunters, successful reproduction, and changes in harvest levels, are also decisions outside of US Forest Service control, which can affect population trends.

Table 5.6 depicts the historical wild turkey harvest data for the last ten years. Table 5.5 presents the age structure of the harvest by region and shows the percentage of juvenile birds in the harvest. Percentage of juvenile birds in the harvest is an indicator of the reproductive success from the previous year.

Table 5.6. Statewide Historical Wild Turkey Harvest, 1991-2001.

Year	Harvest	% Change from Previous Year
1991	1,818	-
1992	2,225	+22.4
1993	2,073	-6.8
1994	2,515	+21.3
1995	2,650	+5.4
1996	2,559	-3.4
1997	2,890	+12.9
1998	4,250	+47.1
1999	5,340	+25.6
2000	6,827	+27.8
2001	8,417	+23.3

Table 5.7 Historical Reported Wild Turkey Harvest in Carteret, Craven and Jones Counties, 1978-1999

Year	Counties			Total
	Carteret	Craven	Jones	
1978	0	1	0	1
1979	0	0	0	0
1980	0	0	0	0
1981	0	0	0	0
1982	1	0	0	1
1983	0	1	1	2
1984	0	0	1	1
1985	2	0	1	3
1986	1	0	1	2
1987	0	0	2	2
1988	0	0	1	1
1989	0	0	0	0
1990	0	3	0	3
1991	0	1	0	1
1992	2	9	0	11
1993	1	12	0	13
1994	2	17	0	19
1995	5	13	0	18
1996	7	28	15	50
1997	4	20	43	67
1998	5	25	61	91
1999	4	47	60	111
2000	4	60	73	137
2001	3	73	98	174

Black Bear

The North Carolina Wildlife Resources Commission tracts black bear populations annually. Using data collected by NCWRC, the Forest Service can use the information to estimate trends in response to active management. Black bear populations are divided into regions based on counties. The Croatan National Forest falls into District 2.

The black bear populations are monitored through harvest data, mortality data, and are supplemented with nuisance complaints. Nuisance complaints are not useful indicators of actual bear population trends due to increasing human populations and increasing homebuilding in rural areas. However, the nuisance complaint trends do demonstrate ‘cultural carrying capacity’ or the population level with which local people can or will peacefully co-exist with bears.

Population Dynamics: Bear harvest in Coastal North Carolina was fairly stable until 1986. Since 1986, seasons have been established in 14 counties in the northeastern section of the state. The last of these counties opened in 1995. From 1991-1994, harvest was fairly stable in eastern NC. Three additional days were added to the season in 1995 in order to provide additional opportunity for hunters and to slow population growth in some areas where populations appeared to be approaching “cultural carrying capacity”. In 1999, the northeastern season was expanded to an 18-day season. The current emphasis is on monitoring the stability of the harvest. Population models indicate that the Coastal Region’s bear population may be stabilizing following increased harvests in the last 4 years (Table 5.8). The harvests of 929 in 2000-2001, 881 in 1999-2000, and 879 in 1998-1999, respectively, are the highest harvests ever reported. The harvest levels for counties that contain the Croatan National Forest have progressively increased over the last 14 years, indicating an increasing population trend (Table 5.9).

Observed mortalities of black bears are those documented by NCWRC biologists and represent all known mortalities due to vehicles, depredation, illegal kills, and unknown causes (Table 5.10). Of observed mortalities, 111 of 749 (14.8%) were caused by non-harvest factors. Vehicle mortalities accounted for 5.6% (n=89) of total known mortality (n=1601) in 2000 while prior to 1999, vehicles accounted for an average of 9-11% of total mortality. On the Coast, road kills accounted for 67 mortalities in 2000. This number is below average (n=73) for Coastal roadkills over the last 5 years with 67 bears killed by vehicles in 1995, 47 in 1996, 93 in 1997, 95 in 1998, and 63 in 1999. The opening of new seasons and an increase in season length may account for some bears that might otherwise die in vehicle-related accidents.

Reproductive information was obtained from 73 females in 2000 on the Coast (Table 5.11). The average ovulation incidences of 2.21 for 5+ year-old females on the Coast are comparable to previous good years. In 1999, a high percentage of 2.75 year-old bears showed breeding activity in the Coastal region of the state (100%). In 2000, sample sizes were lower but only 50% of 2.75 year-old bears showed breeding activity in the Coastal region. In addition, 62.5% of Coastal 3 year-olds had placental scars indicating implantation of a fertilized egg. These young ages of first breeding and reproduction have a tremendous positive impact on the population dynamics of black bears and may partially explain the population increase seen on the Coast over the last decade. Black Bear populations are well established in most suitable habitat on the Coast.

Plan expectations: The trend in the black bear population should continue to increase due to maintenance of contiguous habitat, decreases in road density, and providing soft mast. However, it is important to note that black bear habitat provided on the Croatan National Forest is only a portion of the overall habitat provided in the coastal area that supports the population. Activities such as hunting seasons, number of hunters, successful reproduction, and changes in harvest levels, are also decisions outside of US Forest Service control, which can affect population trends.”

Table 5.8 Historical Summer Brood Survey Results, 1988-2000

Year	Number of bear harvested
2000-2001	929
1999-2000	881
1998-1999	879

Table 5.9 Reported Black Bear Harvest in Carteret, Craven and Jones Counties, 1976-1999

Year	Counties			Total
	Carteret	Craven	Jones	
1976	0	ns	7	7
1977	5	ns	14	19
1978	8	ns	8	16
1979	6	ns	9	15
1980	6	ns	9	15
1981	10	ns	6	16
1982	13	ns	ns	13
1983	9	ns	16	25
1984	7	ns	23	30
1985	11	ns	14	25
1986	18	ns	17	35
1987	7	ns	11	18
1988	8	ns	25	33
1989	12	23	24	59
1990	18	14	40	72
1991	18	18	35	71
1992	21	13	37	71
1993	23	23	31	77
1994	16	24	43	83
1995	21	39	58	118
1996	16	26	42	84
1997	10	26	80	116
1998	12	37	85	134
1999	18	53	73	144
2000	29	45	65	139

Table 5.10. Observed Black Bear Mortality in District 2, 2000.

Cause of Mortality						
County	Hunting	Vehicle	Depredation	Illegal	Other	Total
Beaufort	34	15	0	0	0	49
Carteret	1	0	0	0	0	1
Craven	14	2	0	0	0	16
Duplin	2	3	0	0	0	5
Lenoir	0	1	0	0	0	1
New Hanover	0	1	0	0	0	1
Jones	29	6	0	0	0	35
Onslow	21	1	0	0	0	22
Pamlico	13	0	0	0	0	13
Pender	5	7	0	0	0	12
Pitt	0	0	0	1	0	1
Total	119	36	0	1	0	156

Table 5.11. Coastal Region Black Bear Reproductive Performance by Age Class, 2000.

Age (Years + $\frac{3}{4}$)	n	Percent Ovulating	Ovulation Incidence ^a	Percent w/ Placental Scars	Percent w/ Placental Scars & CL
1	10	0.0	N/A	0.0	0.0
2	6	50.0	1.33	0.0	0.0
3	8	50.0	1.75	62.5	12.5
4	11	36.4	2.25	81.8	18.2
5+	38	36.8	2.21	76.3	18.4
Total	73				

^aDerived from females that ovulated

5.4.2 Background Information for Monitoring Habitats

The CNF Plan proposes active management in predominantly 5 Ecological Classification System Landtypes. Within these landtypes and associated management prescriptions, individual species are monitored to measure effects (Management Indicator Species). The remaining 3 Landtypes either have no management activities proposed or the management activities are limited in amount and distribution to only have minor, localized effects. To better gauge the effects from management, these landtypes (i.e. habitats) will be monitored for change due to management activities.

The landtypes that will be monitored are lake and stream swamps, tidal streams and estuaries, and maritime ridges and dunes. These landtypes correspond to the hardwood cypress wetland and pocosin lake management prescriptions.

Aquatic habitat: Aquatic habitats are monitored on the Croatan through a joint effort with the North Carolina Division of Marine Fisheries, North Carolina Wildlife Resources Commission (NCWRC), NC State University, Forest Service personnel, and other state agencies. An aquatic classification was developed for the CNF Plan to guide both regional planning as well as displaying the range of ecological types across a landscape. Using the biological and habitat

inventory information developed at reference sites can be used to extrapolate to uninventoried sites at other locations (Appendix H). Fourteen aquatic ecological types were identified. These ecological types are the basis for monitoring aquatic habitats, and are designated by number in the following discussion.

Currently, large tidal rivers (2), tidally influenced sections of large creeks (3), large acidic natural lakes (7), and acidic and nonacidic ponds (8&9) are monitored cooperatively with the NCWRC. Monitoring non-tidal midreaches of large streams (4) is challenging due to the difficulty in gaining access.

The approach to monitoring aquatic habitats begins by taking the spatial data for the 11 aquatic ecological types and seeing how and where they occur on the Forest. For the most part, all of the aquatic ecological types (i.e. habitats) can be monitored using several key water quality parameters (e.g. salinity, pH, dissolved oxygen, conductivity). These data are cost effective to collect, and reliable indicators.

Historic fish data exists from across the Croatan National Forest that can be associated with each habitat type, and therefore associate any changes in fish community based on changes in water quality (i.e. habitat). Trend data are being developed for large rivers and ponds/lakes on the Forest. However, it will be several more years until a reliable data set is available.

Another aquatic habitat monitoring element is the utilization of Forest waters by anadromous species. The year 2002 is the 3rd year of data collection on the first 3-year assessment (eels and striped bass). The next 3-year assessment will analyze “bait fish”, such as mullet.

Due to the difficulty in obtaining accurate or reliable data, several aquatic ecological types are not considered in the monitoring plan. These include acidic and nonacidic upper reaches of large streams, estuarine branches and creeks. The pocosin and dense forest vegetation, as well as swampy lowlands have too much hydrologic connectivity to capture fish with any reliability and without the use of piscicides, which is not a desired action.

Terrestrial Habitat (least affected landtypes) – To monitor the hardwood cypress wetland management prescription (which include landtypes maritime ridges and dunes, and lake and stream swamps), these areas will be inventoried and mapped for old growth conditions. Portions of these areas are also included in the breeding bird survey routes, which is part of the Regional Landbird Conservation Strategy that helps to measure health of the overall system. On the Croatan National Forest, only 4 locations totaling 45 acres exist of the maritime ridge and dune forest landtype. However, this landtype is common outside the Forest. Ten acres of this landtype is proposed for restoration on the Croatan. Plots will be established in restoration areas to measure success.

Using data collected from the breeding bird surveys conducted across the state, population estimates and trends may be established at the state and regional scale. Two routes for breeding bird surveys are used on the Croatan National Forest, the Newport Route and Broad Creek Route (Tables 5.12 and 5.13). Information for statewide trends indicates positive trends for both the prothonotary warbler and pileated woodpecker at rates of +2.5% and +1.5% respectively.

Between 1966 and 1979, the prothonotary warbler and pileated woodpecker had positive trends of +9.8% and +5.2% respectively. Between 1980 and 1999, the prothonotary warbler had a +1.7% trend. However, during the same years, the pileated woodpecker had a negative trend of -0.9%. The prairie warbler did not have adequate data for reliable trend estimation. However, based on data available indications are that statewide overall the trend is down by -1.8%, with the time between 1966 and 1979 showing a -11.5% trend. The years between 1980 and 1999, however, showed an upswing in the trend by +0.6%.

Although the population trends for neotropical migratory birds are an important issue, the Forest Service only has control over part of the habitat (hardwood cypress wetlands). The Plan proposes few, low impact and relatively infrequent activities that would affect the habitat. A larger area than the CNF would be needed to determine meaningful population levels and trends. Monitoring the habitat of neotropical migratory birds, by inventorying and mapping the old growth condition found within the habitat, is more useful for managers since it monitors the condition of landtypes least affected by management activities, but checks that habitats are progressing toward desired conditions.

To evaluate the effectiveness of management and the level of human disturbance within Natural Areas, the conditions of element occurrences will be measured and element occurrence records will be updated. The presence, absence, or reappearance of element occurrences, can be used to indicate the level of, and effects from, human disturbances. Several objectives propose management and protection of Natural Areas, such as inclusion during prescribed burning, exclusion from salvage activities, and consideration of allowing natural processes to function. By monitoring the condition of element occurrences within the Natural Areas, the effectiveness of management and protection activities can be gauged.”

<i>Table 5.12 Breeding Bird Survey, Broad Creek Route</i>			
Year	Number of Birds Recorded		
	<i>Prothonotary Warbler</i>	<i>Prairie Warbler</i>	<i>Pileated Woodpecker</i>
1993	8	19	4
1994	12	3	3
1995	6	4	4
1996	4	7	0
1997	5	12	4
1998	6	11	2
1999	14	14	4
2000	8	9	6

<i>Table 5.13 Breeding Bird Survey, Newport Route</i>			
Year	Number of Birds Recorded		
	<i>Prothonotary Warbler</i>	<i>Prairie Warbler</i>	<i>Pileated Woodpecker</i>
1995	4	2	1
1996	7	12	0
1997	4	11	0
1998	6	2	3
1999	5	12	2

5.4.3 Background Information for Monitoring Public Use and Customer Satisfaction

The CNF Plan outlines a strategy for managing the public use of the Croatan National Forest in a way that meets the needs and desires of the public, while ensuring the natural resources are sustained. The Plan strives to meet the desires and needs of local communities, visitors, residents and the economy. It also strives to change past uses that are currently not being provided in a sustainable manner.

The monitoring question for this category functions to measure whether the opportunities being provided are sustainable, satisfactory, safe, and desirable. This question also requires measures to determine whether the changes proposed to current management are solving the problems identified during the planning process.

In 1998 a recreation sampling system was developed by research and forest staff that would be cost effective and provide statistical recreation use information at the forest, regional and national level. The NVUM project is the permanent sampling protocol that was developed and implemented nationally to gauge the importance of, and satisfaction with, recreational opportunities within the national forest system. The NVUM is administered once every four years on every national forest in the country. The National Forests in North Carolina participated in the National Visitor Use Monitoring project (NVUM) from October 2000 through September 2001. The results collected are valid and applicable only at the forest level, and not intended to be accurate at the district or site level (NVUM Report June 2002). The sampling results can therefore not be applied specifically to the Croatan National Forest. To answer what and how much people are doing on the Croatan National Forest, and to what extent they are enjoying the experience, information needs to be collected that is specific to the CNF.

Using the sampling protocol as the NVUM utilized, information will be collected for the Croatan National Forest sometime between 2002 and 2006, when the next scheduled sampling will occur for all the National Forests in North Carolina. Questions that pertain specifically to the CNF will be developed to focus the results on answering the monitoring question. It will be vitally important to ensure statistically accurate and useful data is collected. To do this the preliminary sample design, sampling unit selection, sample size and variability, and survey implementation must be developed in coordination with District, Forest and Research input.

The Plan outlines several recreational projects to increase capacity of recreational facilities and trail miles, in addition to focusing recreational activities on wildlife and fishing interests. Collecting additional information through a localized NVUM project will help to validate the assumptions made during the planning process that the public's interest in recreation was hunting, picnicking, swimming, and included a desire for increased trail miles and a variety of facilities ranging from rustic to developed (Appendix B of FEIS outlines the perception of recreation needs during the planning process.). The NVUM results for the National Forests in North Carolina for the top 10 recreational activities and top 10 facility/area uses indicate some consistency between the assumptions made during the planning process and the data collected (Table 5.14).

Table 5.14 Percentage of Participation and Use of the top 10 Activities/Top 10 Facilities based on NVUM results for National Forests in North Carolina

Activity	Percentage of Participation
1. Viewing natural features such as scenery, flowers, etc	70.3
2. General/other – relaxing, hanging out, escaping noise or heat	49.7
3. Viewing wildlife, birds, fish, etc	48.2
4. Hiking or walking	46.0
5. Driving for pleasure	41.0
6. Picnicking and family day gatherings in developed sites	20.0
7. Fishing- all types	19.1
8. Nature Study	14.3
9. Visiting a nature center, nature trail or visitor info services	13.1
10. Primitive camping	10.7
Facility	Percentage of Use
1. Hiking, biking, horseback trails	55.0
2. Scenic byway	46.5
3. Picnic area	29.0
4. Visitor center, museum	28.6
5. Other forest road	23.6
6. Interpretive site	15.1
7. Developed campground	13.1
8. Designated wilderness	8.4
9. Swimming area	4.5
10. Designated Off Road Vehicle area	4.2

Visitor satisfaction of facilities will be measured to gauge not only what is or isn't satisfactory, but also what is important to their recreational experience. Grouping these responses helps to prioritize limited resources based on what is important but may not be satisfactory, rather than expending resources on unsatisfactory but also unimportant aspects of the recreational experience.

Using the science based survey format, a survey will be conducted on the Croatan National Forest within 5 years of implementation of the Plan, and alternating with the national survey cycle of once every four years. Questions that pertain specifically to the CNF will be developed to focus the results on answering this monitoring question. The Plan outlines several recreational projects to increase capacity of recreational facilities and trail miles, in addition to focusing recreational activities on wildlife and fishing interests. Collecting additional information through the survey will help to validate the assumptions made during the planning process that the public's interest in recreation was water-based and included the need for increased trail miles and a variety of facilities ranging from rustic to developed (Appendix B of FEIS outlines the perception of recreation needs during the planning process.).

5.4.4 Background Information for Local Communities

Collaboration with other government agencies and local communities has occurred informally over the last 10-15 years. Statistics for baseline information are not available at this time. The planned expectations are more frequent collaborative efforts in the future.

References

- Anderson, Hal E., 1982. Aids to determining fuel models for estimating fire behavior. General Technical Report INT-22. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station, 22 pp.
- Arthur Carhart National Wilderness Training Center. 2002. Minimum Requirement Decision Guide [Online] <http://carhart.wilderness.net>.
- Ash, A.N.; McDonald, C.B.; Kane, E.S.; Pories, C.A. 1983. Natural and modified pocosins; literature synthesis and management option. FWS/OBS-83/04. Washington, D.C.: U.S. Department of Interior Fish and Wildlife Service, Division of Biological Services, 156 pp.
- Brown, J.H.; Heske, E.J. 1990. Control of a desert-grassland transition by a keystone rodent guild. *Science*. 250(4988):1705-1707.
- Conner, R.N.; Rudolph, D.C. 1995. Excavation dynamics and use patterns of red-cockaded woodpecker cavities: relationships with cooperative breeding. In: RED-COCKADED WOODPECKER RECOVERY, ECOLOGY, AND MANAGEMENT, Center for Applied Studies, College of Forestry, Stephen F. Austin State University.
- Dickson, J.G.; Williamson, J.H.; Conner, R.N.; Ortego, B. 1995. Streamside zones and breeding birds in eastern Texas. *Wildlife Society Bulletin*. 23(4):750-755.
- Davis, M.D. 1996. Extent and Location: Chapter 2. In: Davis, M. D., ed., EASTERN OLD GROWTH FORESTS. Washington, D.C.: Island Press: pp. 18-34.
- Dunning, J.B.; Danielson, B.J.; Bulliam, H.R. 1992. Ecological processes that affect populations in complex landscapes. *Oikos*. 65: 6 pp. Federal Wildland Fire Management Policy and Program Review, Draft Report, June 9, 1995. U.S. Department of Interior, U.S. Department of Agriculture.
- Ferguson, Joe. Air quality and prescribed fire course for the future. Unpublished draft on file: Tallahassee, FL: National Forests in Florida.
- Forman, R.T.; Godron, M. 1986. LANDSCAPE ECOLOGY. New York: John Wiley & Sons. 619 pp.
- Frost, C.C. 1993. Four centuries of changing landscape patterns in the longleaf pine ecosystem. In: Proceedings of the Tall Timbers Fire Ecology Conference, No.18. 25 pp.
- Frost, C.C. 1995 Presettlement vegetation and natural fire regimes of the Croatan National Forest. Prior conditions documentation prepared for the Croatan National Forest, U.S. Forest Service, New Bern, N.C. November 30, 1995 (unpublished).
- Frost, C.C. 1996. Presettlement vegetation and natural fire regimes of the Croatan National Forest. North Carolina Department of Agriculture, Plant Conservation Program. 128 pp.
- Frost, C.C.; Walker J.; Peet R.K. 1986. Fire-dependent savannas and prairies of the southeast: original extent, preservation status and management problems. In: Kulhavy, D.L. and Conner, R.N., eds. WILDERNESS AND NATURAL AREAS IN THE EASTERN UNITED STATES. Nacogdoches, TX: Center for Applied Studies, School of Forestry, Stephen F. Austin State University.
- Fussell, J.O.; Wilson, J. (Kraus) 1980. Natural areas inventory of Carteret County, North Carolina. Report prepared for the North Carolina Natural Heritage Program. Coastal Energy Impact Program, Office of Coastal Management, DNRCD, Raleigh, NC.
- Healy, W. H. 1991. Trends in management of oak forest for wild turkeys. In: Conference proceedings, oak resource in Upper Midwest-implications for management: 45-55.

- Hellgren, E.C.; Vaughan, M.R.. 1988. Seasonal food habits of black bears in Great Dismal Swamp, Virginia and North Carolina. *Proceedings, Annual Conference Southeast Association Fish and Wildlife Agencies*. 42:295-305.
- Hamel, P.B. 1992. *LAND MANAGER'S GUIDE TO THE BIRDS OF THE SOUTH*. Chapel Hill, NC: The Nature Conservancy, Southeastern Region. 437 pp.
- Hillman, L.L.; Yow, D.L.. 1986. Timber management for black bear. *Proceedings, Eastern workshop bear research and management*.
- Hooper, R.G. 1988. Longleaf Pines Used for Cavity Trees by Red-Cockaded Woodpeckers. *Journal of Wildlife Management*. p. 7.
- Hungerford, Roger D.; Frandsen, William H.; Ryan, Kevin C. 1995. Ignition and burning characteristics of organic soils. In Cerulean, Susan I.; Engstrom, R. Todd eds. *Fire in wetlands; a management perspective*. *Proceedings of the Tall Timbers Fire Ecology Conference*, No. 19. Tall Timbers Research Station, Tallahassee, FL. 78-91.
- Hughes, R.H. 1966. Fire ecology of canebrakes. In: *Proceedings of the Tall Timbers Fire Ecology Conference*, No. 5. Tallahassee, FL: Tall Timbers Research Station. 149-157.
- Hunter, C. 1997. South Atlantic coastal plain bird conservation plan. Unpublished draft on file: Atlanta, GA.
- Hunter, M. 1991. Coping with ignorance: The Coarse-Filter Strategy for Maintaining Biodiversity. Pp. 256 281 K.A. Kohm, ed., *BALANCING ON THE BRINK OF EXTINCTION THE ENDANGERED SPECIES ACT AND LESSONS FOR THE FUTURE*. Island Press, Washington, D.C.
- Jackson, J.A. 1977. Red-cockaded woodpeckers and pine red heart disease. *Auk* 94: 3 p.
- Jackson, J.A.; and Jackson, B.J.S. 1986. Why do red-cockaded woodpeckers need old trees? *Wildlife Society Bulletin*. 14: 6 p.
- Jenkins, R.E. 1976. Maintenance of Natural Diversity: Approach and Recommendations. Pp. 441 451 *Transactions of the 41st North American Wildlife Conference*, 4 March 1976, Washington, D.C. Wildlife Management Institute, Washington, D.C.
- Jenkins, R.E. 1985. Information methods: Why the Heritage Programs work. *The Nature Conservancy News* 35(6):21-23.
- Keller, C.M.; Robbins, C.S.; Hatfield, J.S. 1993. Avian communities in riparian forests of different widths in Maryland and Delaware. *Wetlands* 13: 37-144.
- Kelley, J.F.; Bechtold, W.A. 1990. The Longleaf Pine Resource. In: *Proceedings of the Symposium on the Management of Longleaf Pine*. Gen. Tech. Rep. SO-75. Starksville, MS: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 11 pp.
- Korschgen, L.J. 1967. Feeding habits and foods. In: Hewitt, O.H. (ed.) *THE WILD TURKEY AND ITS MANAGEMENT*. Washington, D.C.: Wildlife Society. pp. 137-198.
- Landers, Larry; Wade, Dale. 1993. Disturbance, persistence and diversity of the longleaf pine-bunch-grass ecosystem. A paper presented at the Fire Working Group Technical Session at the Society of American Foresters National Convention. Indianapolis, IN. November 7-10, 1993.
- Landers, J.L., Hamilton, R.J.; Johnson, A.S.; Marchinton, R. L. 1979. Foods and habitat of black bears in southeastern North Carolina. *Journal of Wildlife Management*. 43:143-153.
- Lavdas, L. G. 1996. Program USMOKE — Users Manual. General Technical Report SRS-6. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 147 pp.

- Ligon, J.D. 1970. Behavior and breeding biology of the red-cockaded woodpecker. *Suk* 87. p. 23.
- Lillard, R.G. 1947. *THE GREAT FOREST*. New York: Alfred A. Knopf.
- Long, Ellen Call. 1990. Forest fire in southern pines. *Forest Leaves*. 2 (6):94.
- Maehr, D.S. 1984. Distribution of Black Bears in Eastern North America. *BLACK BEAR RESEARCH AND MANAGEMENT*. 7: 74-75.
- MCAS Cherry Point. "Mission and History". [Online] August 13, 2002.
<http://www.cherrypoint.usmc.mil>
- McGarigal, K.; Marks, B.J. 1995. FRAGSTATS: spatial pattern analysis program of quantifying landscape structure. General Technical Report PNW-GTR-351. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 122 p.
- Mixon, R.B.; Pilkey, O.H. 1976. Reconnaissance geology of the submerged and emerged coastal plain province, Cape Lookout area, North Carolina. Geological Survey Professional paper. 859.
- National Commission on Wildfire Disasters Report, 1993. Printing supported by American Forests.
- 1990 Census of Population and Housing, North Carolina.
- National Wildfire Coordinating Group Incident Operation Incident Operations Standards Working Team, 1996. Glossary of Wildland Terminology. Boise, ID: National Interagency Fire Center.
- The Nature Conservancy. 2000. Biological Conservation Database.
- N.C. Dept Environment, Health and Natural Resources. 1990. Best Management Practices for Forestry in the Wetlands of North Carolina.
- North Carolina. 1989. Forest Practice Guidelines Related to Water Quality. North Carolina Administrative Code 15A NCAC 11 .0100-.0209.
- Noss, R.F. 1987. From plant communities to landscapes in conservation inventories: A look at The Nature Conservancy (USA). *Biological Conservation*, 41:11-37.
- Pelton, M.R. 1986. Habitat needs of black bears in the East. In: Kulhavy, D.L.; Conner, R.N. (des.) *WILDERNESS AND NATURAL AREAS IN THE EASTERN UNITED STATES: A MANAGEMENT CHALLENGE*. Nacogdoches, TX: Stephen F. Austin State University. 49-53.
- Ranney, J.W.; Bruner, M.C.; Levenson, J.B. 1981. The importance of edge in the structure and dynamics of forest islands. *In*: Burgess, R.L.; Sharpe, D.M., eds. *FOREST ISLAND DYNAMICS IN MAN-DOMINATED LANDSCAPES*. New York: Springer-Verlag: 26 pp.
- Rudis, V.A.; Tansey, J.B. 1985. Regional assessment of remote forests and black bear habitat from forest resource surveys. *Journal Of Wildlife Management*. 59(1): 170-180.
- Rural Fire Protection in America, 1992. Rural Fire Protection in America Steering Committee, U.S. Department of Agriculture, Forest Service, Northeastern Area State and Private Forestry. Radnor, PA.
- Schafale, M.P.; Weakley, A.S. 1990. Classification of the natural communities of North Carolina. Third Approximation. Raleigh: North Carolina. Natural Heritage Program.
- Strelke, W.K.; Dickson, J.G. 1980. Effect of forest clearcut edge on breeding birds in Texas. *Journal of Wildlife Management*. 44: 8 pp.
- Trapani, Elena. "Seasonal Variations in Surface Water Chemistry and Fire Effects on a Pocosin Lake: Great Lake in Croatan National Forest, North Carolina" Masters Thesis. East Carolina University. 1998.

- U.S. Department of Agriculture, Forest Service. 1989. Position statement on national forests old-growth values. Unnumbered internal memo to regional foresters, station directors, and Washington Office staff, October 11, 1989. Unpublished draft on file: Washington, DC.
- USDA, Forest Service, 1997. Guidance for conserving and restoring old growth forest communities on national forests in the southern region. Forestry Report R8-FR 62. p. 124.
- Van Lear, David H.; Waldrop, Thomas A., 1985. Current practices and recent advances in prescribed burning. Clemson, SC: Clemson University, Department of Forestry. 14 pp.
- Walters, R.J. 1997. Population and management studies of red-cockaded woodpecker on Croatan National Forest, 1988-1997 (internal report). USFS National Forests in North Carolina. 25 p.
- Williams, Jerry T., 1994. Fire's role in support of ecosystem management. A paper presented at the Biswell Symposium. Walnut Creek, CA. February 15-17, 1994.
- Wilson, L.A. 1995. LAND MANAGER'S GUIDE TO THE AMPHIBIANS AND REPTILES OF THE SOUTH. Chapel Hill, NC: The Nature Conservancy, southeastern region. 360 pp.
- Weigl, P.D., Steele, M.A.; Sherman, L.J.; Ha, J.C.; Sharpe, T.S. 1989. The ecology of the fox squirrel (*Sciurus niger*) in North Carolina; implications for survival in the Southeast. Tall Timber Resource Stat. Bulletin. No. 24. 93 p.
- Wergowski, D. 1995. Evaluation of ambient airborne particulate matter concentrations in the Southern Appalachian assessment — with implications for forest land management. Unpublished draft on file: Atlanta, GA: U.S. Department of Agriculture, Forest Service, Region 8.