Ecological Zones of the Nantahala and Pisgah National Forests

Contents

Overview of Ecological Zones

The Nantahala and Pisgah National Forests are distributed across 18 counties in western North Carolina providing the largest amount of public lands available in the region. They are located in the Blue Ridge Physiographic Province of the Southern Appalachian Mountains. The Blue Ridge forms a southwest to northeast mountain range through western North Carolina with many areas over 4,000 feet in elevation. Elevations in the Nantahala and Pisgah NFs range from less than 1,050 feet to greater than 6,200 feet.

Geologic processes (fluvial, mass wasting, groundwater movement, etc.), materials (bedrock and surficial deposits), structures (fracture systems, folds, faults), and landforms control or influence a host of ecological factors, such as slope aspect (solar radiation); slope steepness; the distribution and composition of soil parent material and associated vegetation; the characteristics of floodplains, wetlands, riparian areas, and streams; the quantity and quality of surface water and groundwater; natural disturbance regimes; and the nature and condition of watersheds. Geological diversity is the foundation of ecosystem diversity and biological diversity.

The relationship of geology to site fertility is a basis for the Ecological Zones in the Southern Appalachians: first approximation by Simon and others (2001). Ecological zones are defined as units of land that can support a specific plant community or plant community group based upon environmental factors such as geology, temperature, moisture, fertility, and solar radiation (Simon 2011). Ecological zones were modeled as multivariate logistic functions of climatic, topographic, and geologic variables. Results of this model suggest that bedrock geology is an important factor affecting the distribution of vegetation. The presence or absence of the plant communities typically associated with an ecological zone is a reflection of past disturbance events including land use changes. Absence of the expected plant communities may serve as an indicator for potential restoration.

A combination of geology and past and current land use has shaped the present vegetative composition and abundance of habitats across the forests. Table 1 identifies the 11 ecological zones that include the majority of the lands across the Nantahala and Pisgah NFs. The final number of ecological zones (ecozones) was derived by analyzing the diversity of types and combining those with similar abiotic environments and ecological functions. A diversity of plant communities may be represented in any single ecozone. All the applicable plant communities are listed in Table 1 and were derived from either Natureserve.org, from the Guide to the Natural Communities of North Carolina, 4th Approximation, or from the Ecological Zones in the Southern Blue Ridge, 3rd Approximation. These plant communities or associations are described in the online edition of the natural community publications at the NC Natural Heritage Program web site (http://portal.ncdenr.org/web/nhp/nhp-publications#natural-communities) or the NatureServe Explorer web database (http://www.natureserve.org/explorer/).

Table 1. Plant communities represented within the 11 ecological zones.

Ecological Zones	Plant Communities
Spruce-Fir	Fraser Fir Forest (Rhododendron and Herb Subtypes), Red Spruce – Fraser Fir Forest (Herb, Rhododendron, Birch Transition Herb, & Low Rhododendron Subtypes)
Northern Hardwood	Northern Hardwood Cove Forest (Typic & Rich Subtypes), Blue Ridge Hemlock Northern Hardwood Forest (acidic subtype)
High Elevation Red Oak	High Elevation Red Oak Forest (Typic Herb, Rich, Heath, Orchard, & Stunted Woodland Subtypes)
Acidic Cove	Acidic Cove Forest (Typic Subtype), Canada Hemlock Forest (Typic & White Pine Subtypes), Chestnut Oak Forest (Rhododendron Subtype)
Rich Cove	Rich Cove Forest (Montane Rich, Montane Intermediate, Foothills Intermediate, Foothills Rich, Red Oak, & Boulderfield Subtypes)
Mesic Oak	Montane Oak-Hickory Forest (Acidic, Basic, Low Dry, & White Pine Subtypes)
Dry-Mesic Oak	Dry-Mesic Oak Hickory Forest, Low Montane Red Oak (?), Montane Oak-Hickory Forest (Low Dry Subtypes)
Dry Oak	Chestnut Oak Forest (Dry Heath, Herb, & White Pine Subtypes)
Pine-Oak Heath	Pine-Oak /Heath (Typic & High Elevation Subtypes)
Shortleaf Pine-Oak Heath	Low Mountain Pine Forest (Shortleaf Pine & Montane Subtypes), Southern Mountain Pine-Oak Forest
Floodplains	Montane Alluvial Forest (Small River & Large River Subtypes)

Each of the ecozones have been modeled and mapped based on data collected from more than 5,000 plots recorded across the Southern Blue Ridge.

For the purpose of assessing the current condition of ecosystems on the Nantahala and Pisgah NFs the Ecological Zones model was applied spatially to the forest. Descriptions of each ecological zone include the composition of species, the vegetative structure of the forest, general disturbance patterns, and wildlife diversity.

In addition to the Ecological Zones model, other data including FSVeg data, the LANDFIRE BioPhysical Settings model, LiDAR (light detection and ranging; a remote sensing technology), and Forest Inventory and Analysis data were used to describe the existing composition and structure of the Nantahala and Pisgah NFs.

The Field Sampled Vegetation database (FSVeg) is the National Forest inventory information for individual sections of the forest called stands. It also includes data about stand ages, tree species and size, and stand descriptors including fuels, down woody material, surface cover, overstory cover and understory vegetation. More information may be found at: http://www.fs.fed.us/nrm/fsveg/index.shtml.

FSVeg spatial data was used in this assessment for the generation of silvicultural and structural age class descriptions by ecozone. FSVeg data (spatial/tabular) was intersected with the Ecological Zones model. Age class distributions for each ecozone were derived using ten-year increments for the silvicultural age class distributions and structural age class grouping based on the BioPhysical Settings Models generated by LANDFIRE (http://www.landfire.gov/index.php).

Table 2. Strengths and limitations of FSVeg spatial data used in the assessment of current ecozone conditions.

Silvicultural Age Class Distribution Data	Structural Age Class Distribution Data
---------------*Strengths*---------------	
1. Easily identifies changes in land use history.	1. Presents age class data within an ecological context
2. Ten-year age class breaks make trends in young forest habitat creation easy to identify by time period.	2. When compared to LANDFIRE model structure comparisons, degree of departure may be estimated.
3. Reflects recent and historic National Forest management and large-scale disturbances.	3. Reflects recent and historic National Forest management and large-scale disturbances.
4. Contains current disturbance data (through Dec 2012)	4. Contains current disturbance data (through Dec 2012)
--------------- *Limitations* ---------------	
1. Portions of the tabular data are outdated	1. Portions of the tabular data are outdated
2. May include unknown mapping errors	2. May include unknown mapping errors
3. May underestimate small scale, natural disturbances such as thunderstorm downbursts	3. May underestimate small scale, natural disturbances such as thunderstorm downbursts
4. Age class increments are mathematical breaks not based on ecological traits.	4. LANDFIRE Model estimations may not be fully reviewed, not contain updated literature, or be based heavily on expert opinion.
	5. LANDFIRE Model estimations of past conditions may be a blurred combination of pre-and post-European settlement conditions.

FSVeg data was also used to develop an estimation of current forest types that occur within the modeled ecozones. Using the process described below, a list of FSVeg forest types within each of the 11 ecozones was generated and described.

In October 2012, a meeting of federal and NC state land management agencies was held to develop a crosswalk between FSVeg forest types, the Ecological Zones model, and NatureServe EcoClassifications, as well as to assess the degree to which the FSVeg forest types could represent the current main overstory in the modeled ecozones. The results of this meeting assisted with the assessment of current vegetation conditions in the modeled ecozones and identification of potential departures (Table 3).

Table 3. Example results from the October 2012 meeting.

Ecological Zones model (Simone et al. 2011)	Nature Serve Eco-Classification	Nantahala & Pisgah Ecozone	Relevant FSVeg Forest Type Codes
Dry Oak Evergreen Heath	Allegheny-Cumberland Dry Oak Forest & Woodland	Dry Oak Heath	45,51,52,57,59,60
Dry Oak Deciduous Heath	Allegheny-Cumberland Dry Oak Forest & Woodland		
Shortleaf Pine-Oak Heath	Southern Appalachian Low Elevation Pine	Shortleaf Pine-Oak Heath	3,12,13,14,16,21,25,32,33,44,49
Low Elevation Pine	Southern Appalachian Low Elevation Pine		

With an agreed upon crosswalk, the intersection of the FSVeg data and the modeled ecozones generated a list of forest types present and associated acres. These forest type/acre combinations were divided into several categories describing their degree of connectedness to the modeled ecozones. This analysis generated an estimate of the acres within an ecozone that contained overstory species (and ideally representative understory species) that were (1) expected to be found there, (2) of close association to the modeled ecozones, or (3) considered uncharacteristic.

Forest types included in the modeled acreage calculations were grouped by similar species and presented in the assessment for each ecozone (Figure 1). The strengths and limitations are listed in Table 5.

Figure 1. Example Nantahala and Pisgah NFs FSVeg forest type breakdown within the Northern Hardwood Ecozone.

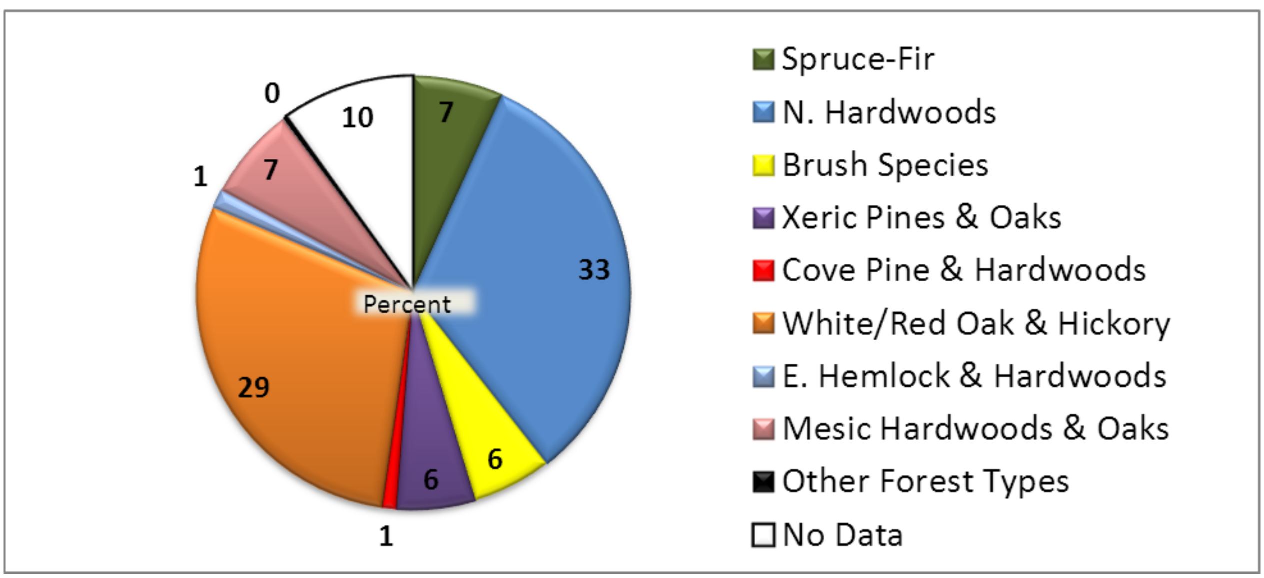


Table 4. Estimating current forest communities using a combination of FSVeg and modeled ecozone data.

Strengths:
1. Applies "current" forest types to a landscape scale ecozone model to depict current forest conditions.
2. When compared to modeled ecozone communities the analysis may give an approximation of departures.
Limitations:
1. Forest type determination may be dated or inaccurate at the scale of the ecozone model.
2. Historic biases in the determination of forest type
3. Inaccuracies in modeled ecozone extent

Forest Inventory and Analysis (FIA) Data (http://www.fia.fs.fed.us/library/)

FIA data from the southern Appalachian Mountains was intersected with the third approximation of the Ecological Zones model (Simon et al. 2011). FIA data plots falling into the different ecozones were analyzed for forest types and grouped according to their relationship to the modeled ecozones. FIA plots where the FIA forest type and ecozone resulted in the strongest match (similar to Table 1 above) were pooled by age groupings that approximated the community seral stages.

Where data was present, the Forest Vegetation Simulator (FVS) was used to summarize data into basal area and trees per acre species group tables. The Stand Visualization System (SVS) was used to develop diagrams of stand structure for those communities based on the FVS data. The tables depict abundance and dominance structures for ecozone representative communities.

FVS: http://www.fs.fed.us/fmsc/fvs/

SVS: http://forsys.cfr.washington.edu/svs.html

Table 5. Deriving and depicting ecozone abundance and dominance conditions using FIA data.

Strengths:
1. Uses recently measured data to depict a range of structural conditions
2. Represents an average of conditions within the age grouping and ecozone
3. Provides a "picture" of species group locations within the communities structure.
Limitations:
1. Represents an average of conditions within the age grouping and ecozone
2. Data varies in robustness across age groupings and ecozones.

LiDAR

LiDAR (Light detection and ranging) is a remote sensing method that uses light in the form of a pulsed laser to measure ranges (variable distances) to the Earth. LiDAR was used in the assessment of forest structural conditions to identify forest canopy openings, canopy height classes, and relative shrub density. LiDAR data for the Nantahala and Pisgah NFs was most recently collected in 2005 (data is a snapshot in time), so any changes in the last seven years are not accounted for when considering the results from LiDAR analysis. Phase II was completed in 2004 and includes McDowell, Burke, Caldwell, Avery and Watauga Counties which includes all the Grandfather Ranger District and a small portion of the Appalachian Ranger District at its eastern edge. The sixteen western most NC counties were completed for the Phase III LiDAR flights in 2005. This covers all of the Nantahala NF, the Pisgah Ranger District, and the majority of the Appalachian Ranger District. The Grandfather was not covered in the Phase III.The number of laser pulses per second for the Phase III coverage area was much greater in comparison to Phase II. It has been hypothesized the fewer number of laser pulses and resultant returns, which characterizes the canopy structure and above ground biomass, distort the average canopy height and understory values.

LiDAR Limitations:

- It does not capture the species composition of a sampled area
- It is a snapshot in time
- Age to height relationship must be estimated and break points set
- Conditions still need to be inferred or ground-truthed

LiDAR Strengths:

- Detailed height and structure information possible
- Density and canopy closure information possible
- Information gathered on several different vegetative levels
- Provides more accurate digital elevation models with increased contour separation
- Enables more accurate identification of drains and roads

Wildlife

R8Bird is the National Forest inventory and monitoring of landbird populations and trends for the Southern Region. The application was developed to support forest planning and plan implementation through comprehensive and consistent monitoring of migratory and resident landbirds. R8Bird was implemented in 1996 as part of the Southern Region Neotropical Migrant and Resident Landbird Conservation Strategy. This represents a continuous seventeen year period with reliable and consistent monitoring data.

R8Bird maintains strict data collection standards and permits comparison of temporal and spatial dynamics of local (i.e. forest) and regional species and guilds. Additionally, at the ranger district level, R8Bird provides information that can be used for analysis and project implementation. The application is also used to share monitoring information with several universities, state agencies, and other cooperators involved with bird conservation.

A primary objective of R8Bird is to monitor the influence of forest management (e.g., prescribed burning, vegetation restoration, etc.) on migratory and resident bird populations. Other uses of R8Bird include identifying species guilds within forest communities, evaluating species diversity and habitat associations at multiple scales, and analyzing species frequency of occurrence.

While it is recognized that there is an abundance of wildlife monitoring information available on a variety of species and groups, R8Bird provides the most comprehensive, consistent, reliable data to examine the effects of the current forest plan on terrestrial wildlife populations. Therefore, it is used most frequently in this assessment. Other wildlife data is referenced where appropriate. This data includes, but is not limited to: nongame species monitoring and game species harvesting data provided by the NC Wildlife Resource Commission, breeding bird survey data provided by the USGS, and mast production monitoring data provided by the NC Wildlife Resource Commission and USFS.

Spruce-Fir Forest Ecological Zone

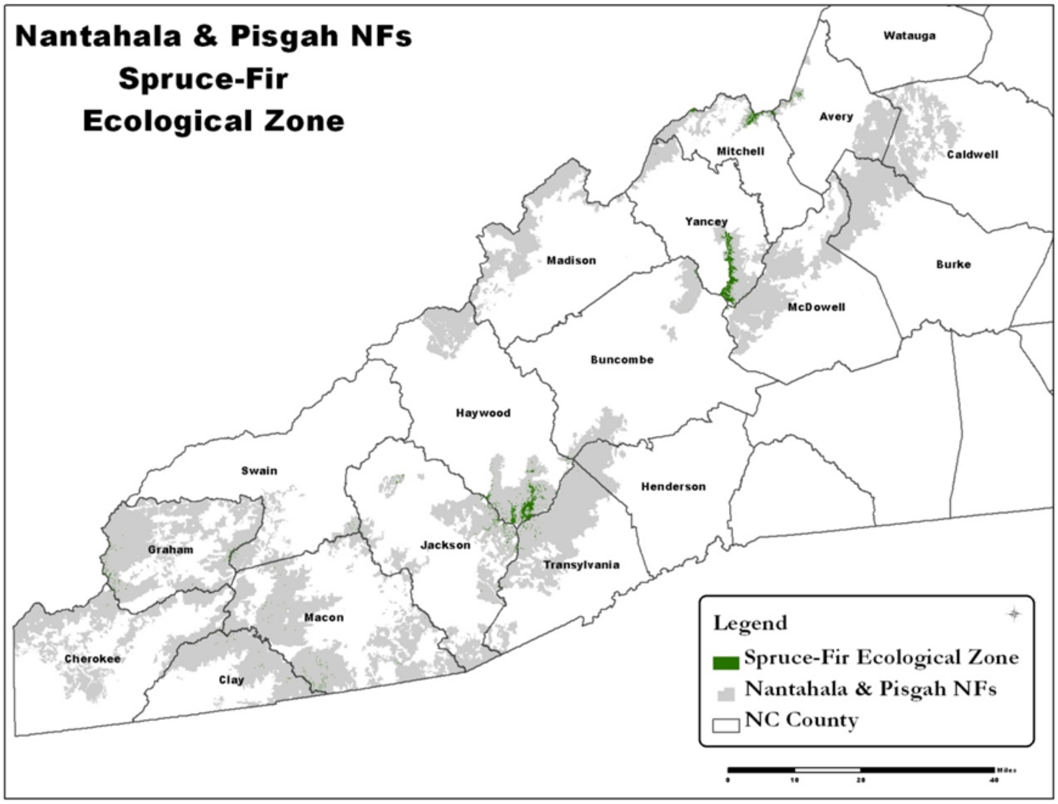
Environmental Setting: The spruce-fir ecological zone occurs at the highest elevations at all exposures and topographic positions from 5,200 to over 6,000 feet in elevation, with some red spruce occurring as low as 4,500 feet. In general, the zone occurs on exposed landforms that are convex in shape (Simon 2011). Moisture content is not limiting and is present both from fog deposition and ambient rainfall. Soils vary from shallow rocky substrates where Fraser fir dominates to deeper mineral soils with a well-developed organic layer in mixed spruce-fir forest. Low temperatures, high winds, frost, and ice are all important natural disturbance events influencing this zone.

Geographic Distribution: This ecological zone ranges from western North Carolina and eastern Tennessee to the southern Virginia Mountains (Natureserve 2013). Fraser fir dominated forests typically only occur above 6,000 feet elevation while the combination with red spruce can extend to 5,200 feet elevation (Schafale & Weakley 1990; TNC 1994). The spruce-fir ecozone covers approximately 1.6% of the Nantahala and Pisgah NFs. In contrast, the spruce-fir ecozone is less abundant (0.9%) in the surrounding 18-county area. All of the subtypes of this group are globally ranked G1, critically imperiled, or G2, imperiled (Natureserve 2013).

Across the Nantahala and Pisgah NFs, the zone covers approximately 16,600 acres spread over six areas (Figure 2) (Smith and Nichols 1999). Spruce-fir forests dominated the southern Appalachians as long as 18,000 years ago and gradually retreated to the highest peaks during the warming period following the last glaciation period 6,000-10,000 years ago (Delcourt and Delcourt, 1993). The ecozone is more common in the Pisgah NF, primarily occurring at Roan Mountain and in the Black Mountains. Portions of the ecozone have been impacted with past land use history. Notably, it no longer occurs within upper portions of the Santeetlah Creek watershed in Graham County and in Graveyard Fields in Haywood County.

As with a large portion of the national forest landscape, past land use (extensive harvest and fire), forest health (balsam woolly adelgid), and climate conditions have altered community compositions within the spruce-fir ecozone. These types of community alterations may have resulted in changes in the proportion of the spruce or fir within a community or increased the amount of deciduous forest vegetation present. In certain cases, what may have originally been a spruce-fir forest is now a hardwood community (i.e. northern hardwoods) or is represented as a non-forest community (i.e. Graveyard fields in Haywood County) (Newell and Peet 1996).

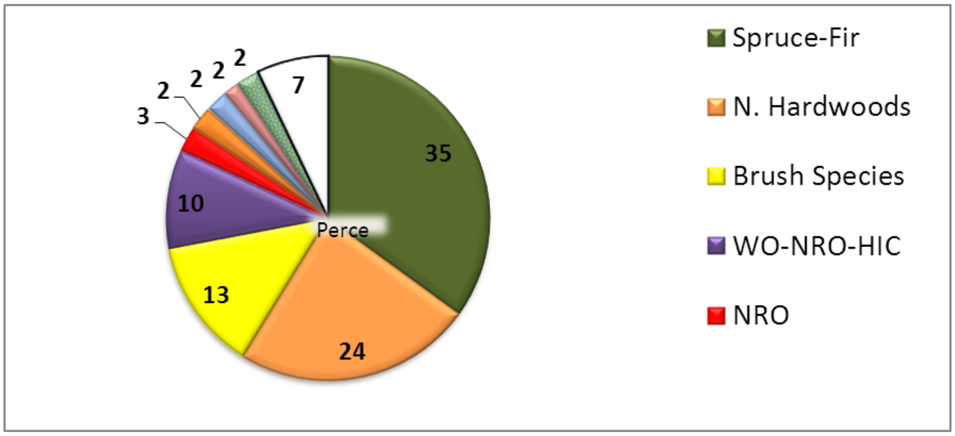
Figure 2. Distribution of spruce-fir ecological zones across the Nantahala and Pisgah NFs.



FSVeg Types

Within Nantahala and Pisgah National Forest lands, the forest vegetation simulator (FSVeg) database identifies 5,850 acres as having components of the spruce-fir community present. This acreage represents approximately 35% of the spruce-fir ecozone. The other 65% of land area within the ecozone includes 8,900 acres identified as forest communities that are typically expected to be adjacent to or in close proximity to the spruce-fir community on the landscape (Figure 3, Busing et al. 1992). Smaller acreages also consist of miscellaneous forest types, which represent less than 2.5 percent of the spruce-fir ecozone.

Figure 3. Nantahala and Pisgah NFs FSVeg forest type breakdown within the spruce-fir ecozone



Composition

This ecozone is dominated by Fraser fir (*Abies fraseri*), red spruce (*Picea rubens*), or a combination of the two with lesser amounts of American ash (*Sorbus americana*), yellow birch (*Betula allegheniensis*), and fire cherry (*Prunus pensylvanica*). Due to the mortality of canopy trees by the balsam woolly adelgid, former Fraser fir-dominated forests are less abundant and have been replaced with red spruce. In the understory, Fraser fir and red spruce continue to be a component of the regeneration, with areas of increased red spruce abundance. The shrub layer ranges from sparse to extremely dense with Catawba rhododendron (*Rhododendron catawbiense*), including Carolina rhododendron (*Rhododendron caroliniensis*) or great laurel (*Rhododendron maximum*) on occasion. Herbaceous diversity is extremely sparse when a dense shrub layer forms, and moderately diverse under a more open midstory layer. Some of the more common herbaceous species include white snakeroot (*Ageratina altissima* var. *roanensis*), bluebead-lily (*Clintonia borealis*), whorled aster (*Oclemena acuminata*), mountain woodfern (*Dryopteris camplyoptera*), and hay-scented fern (*Dennstaedtia punctilobula*). Bryophyte (mosses and liverworts) diversity is high within this zone.

The transition between the spruce-fir ecozone is influenced by elevation, topography, and past land use (Busing et al. 1992). Various plant community associations have been delineated within this zone. Separate Rhododendron and herb Fraser fir subtypes occur on the Nantahala and Pisgah NFs. For mixed red spruce and Fraser fir forests, five subtypes occur across the forest: one dominated by herbs, one by Rhododendrons, one by boulderfields, one by birch transitional herbs, and the final dominated by a Rhododendron maximum type that occurs at the lowermost extent of the zone (Schafale 2012; Natureserve 2013).

Connectedness

Spruce-fir forest occurs as fragmented patches across the Nantahala and Pisgah NFs and throughout western NC. A separation of 30-40 aerial miles currently occurs between spruce-fir concentrations in the Black and Craggy Mountains and along the eastern edge of the Great Smoky and Balsam Mountains. Spruce-fir forest occurs upslope of more common high elevation red oak forest and northern hardwood forest and adjacent to rare habitats such as grassy balds, beech gaps, and heath balds. For facultative high elevation species, the patchiness of this ecozone probably will not affect their distribution, however for obligate species, such as some of the rare liverworts, the ecozone distribution does limit genetic interchange and may result in less competitiveness with biological stressors such as balsam woolly adelgid or environmental stressors such as climate change. In the concentrated areas, patch sizes of this ecozone can be vast, covering areas as large as 500 acres.

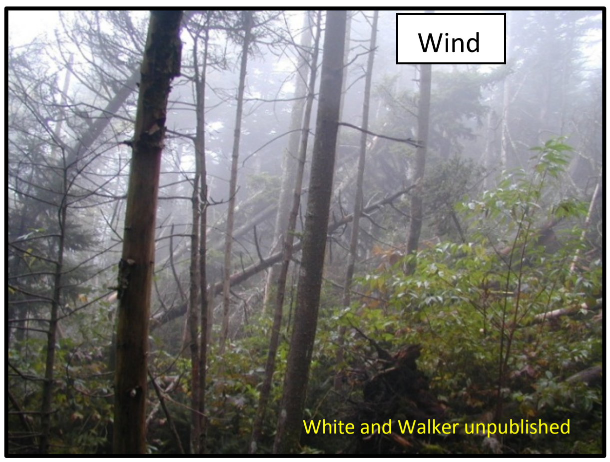
Designated Areas

The majority of the spruce-fir ecozone (91%) is currently within existing designated areas.

Spruce-Fir Ecozone Vegetation Structure

Differences in the structure of the spruce-fir ecozone are related to the species composition shifts with elevation and the disturbances that influence those species. At lower elevations (approximately 4,200 ft), red spruce can dominate or mix with hardwoods (most commonly northern hardwoods), leading to taller crown heights and larger sized trees. Between 5,300 to 6,000 feet in elevation, spruce and fir usually form pure stands. At elevations greater than 6,000 feet, Fraser fir tends to dominate (Whittaker 1956; Nicholas and Zedaker 1989; Beck 1990; Blum 1990; Busing et al. 1993; Collins et al. 2010).

Historic disturbances for the spruce-fir ecozone are related to elevation and topographic conditions where it is found in the Nantahala and Pisgah NFs. At higher elevations, damage from wind in the form of windthrow or crown and stem breakage is common. Winter ice and snow further contribute to the effects of wind, which can exceed 100 mph (Nicholas and Zedaker 1989; Dull et al. 1998). Brusing et al. (1992) hypothesized that frequent wind and ice disturbance was a significant driver in the dominance by Fraser fir over spruce at the highest elevations in the Great Smoky Mountains National Park (GSMNP). Red spruce, which tends to grow larger than fir, is very susceptible to windthrow due to the exposed sites and shallow rocky soils where it grows (Dull et al. 1998). The frequency of winter-related damage was found to increase with elevation especially for spruce, with many trees snapped or uprooted. The highest degree of spruce mortality occurs above 5,500 feet with Fraser fir showing less damage at those same elevations (Nicholas and Zedaker 1989).



Wind derived damage is not the dominant form of mortality on all sites and for all sizes of red spruce and Fraser fir. On shallow soils, where roots are commonly rocked loose in the soil, there is increased risk of desiccation making the effects of droughts readily apparent (Dull et al. 1998). During extended drought in western North Carolina during the late 1990's, southern pine beetle attacked spruce and fir (Rhea, personal communication, Juune 17, 2013).

Regardless of the frequencies of these disturbances, they tend to occur at relatively small scales. Busing and Wu (1990) found little evidence of large-scale disturbance in old-growth spruce stands. After a disturbance, red spruce and Fraser fir both respond favorably to release after many years of suppression. This results in rapid changes in the height of the remaining canopy after a disturbance, though Fraser fir may respond faster in growth (Beck 1990; Blum 1990).

Current tree canopy heights vary greatly across the spruce-fir ecozone reflecting the variety of conditions present (species composition, age classes, topography, height) and the influence of disturbances (balsam woolly adelgid, wind, ice, acidic deposition, historic logging, fire). LiDAR analysis indicated that roughly 1% of the ecozone was in openings (Table 6). Three percent of the ecozone has canopy heights less than five feet and some of these areas are likely to include heath balds. Seven percent of the ecozone contains vegetation canopy heights between 6 and 15 feet. These areas may represent areas regenerating or recovering from balsam woolly adelgid, past harvest, or other disturbance, or represent forest height growth on some of the more nutrient-poor, exposed sites in the southern Appalachians. Forests with canopy heights ranging from 16 to 45 feet cover about 39% of the ecozone. Mature forests (36 to 75 feet) cover 54% of the delineated ecozone. Eleven percent of the spruce-fir ecozone is greater than 75 feet in height. This height class includes both the maximum known heights for Fraser fir (87 feet) and red spruce (110 – 162 feet) (Beck 1990; Harlow et al. 1991). This height class also contains other forest tree species capable of obtaining greater average canopy heights than either red spruce or Fraser fir.

Table 6. LiDAR-derived spruce-fir ecozone canopy height classes.

Height Class (Feet)	Acres in Height Class	Percent of Ecozone in Height Class
0	176	1.1
1-5	455	2.7
6-10	576	3.4
11-15	628	3.8
16-25	1,671	10.0
26-35	2,315	13.9
36-45	2,456	14.7
46-55	2,341	14.0
56-75	4,230	25.3
76-187	1,858	11.1
Totals	16,706	100

Table 7. LiDAR-derived shrub density classes for the spruce-fir ecozone.

Shrub Density Class	Acres	Percent
Class 1 open	2,990	18.0
Class 2, 40-70%	6,419	38.7
Class 3, > 70%	7,171	43.3
Totals	16,580	100

Table 8. LiDAR-derived percent cover for the spruce-fir ecozone.

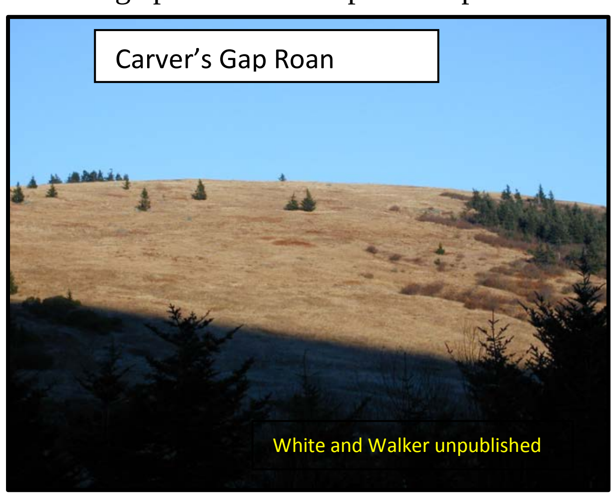
Percent Cover (vegetation > 15’)	Acres	Percent of Ecozone
0	942	5.6
1-10	470	2.8
11-25	645	3.8
26-55	1,727	10.2

Percent Cover (vegetation > 15')	Acres	Percent of Ecozone
56-75	2,487	14.7
76-100	10,620	62.9
Totals	16,891	100

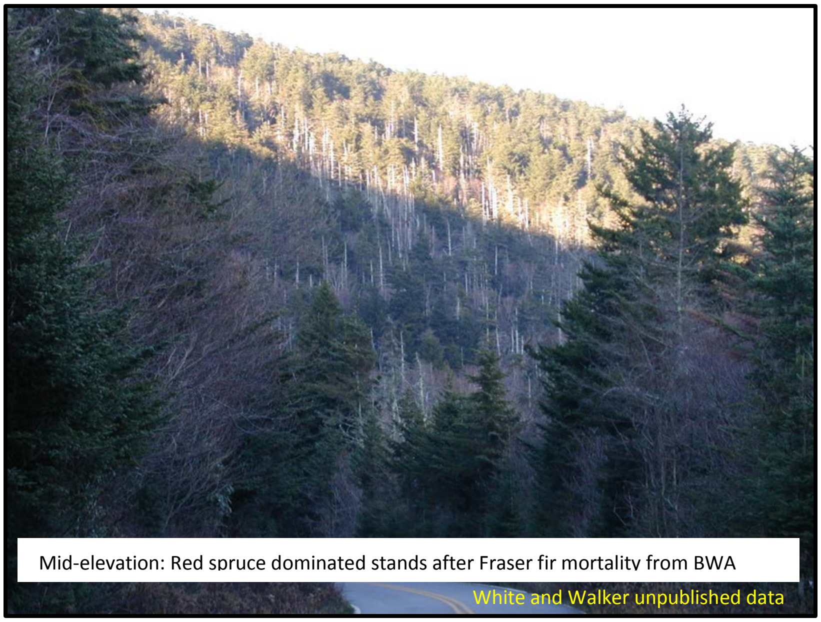
After light to moderate disturbances Fraser fir and red spruce develop ample advance regeneration due to their shade tolerance thus creating dense thickets with high degrees of vertical diversity (Brusing et al. 1992; Collins et al. 2010; Lusk et al. 2010; Morin and Widmann 2010; White and Walker unpublished data). Old growth fir was several times denser at elevations above 5,400 feet (Busing et al. 1992). LiDAR analysis of current disturbance patterns supports this trend of rapid recovery by the spruce-fir community after disturbance. Approximately 6% of the ecozone is open and includes the habitats of some grassy balds and developed facilities such as those found on Roan Mountain. Gaps with up to 10% cover occur across a relatively small portion of the landscape (3%) while gaps with up to 25% cover occur across 4% of this ecozone. Ten percent of the zone has canopy gaps with up to 55% cover. The vast majority of the zone (77%) does not have any discernible canopy gaps (Table 8).

Where light is provided to lower levels of the community, shrub species such as hobblebush (*Viburnum alnifolium*) and smooth gooseberry (*Ribes rotundifolium*) create dense understory conditions (Beck 1990; Blum 1990). Current conditions in the ecozone include high understory densities. Forty-three percent of the ecozone has a shrub and sapling understory density greater than 70%. Only 18% of the existing ecozone has less than a 40% understory density. The predominantly dense understory is consistent with forest dynamics in this ecozone which include the shade tolerance of its principle tree species and high levels of disturbance in the recent past (balsam woolly adelgid).

The uneven-aged structure that was likely present in large portions of the pre-European settlement spruce-fir ecozone was drastically altered during the intensive harvesting in the early 20th century (Pyle and Schafale 1998). In many areas, logging and fires allowed for expansion of hardwood forests (Nowak et al. 2010), resulting in species conversion. In other areas, the spruce and fir regenerated following logging and fire. Other areas did not return to forest cover at all (Roan Mountain or Graveyard Fields for example). The mature even-aged structured spruce-fir forest that developed after the era of intensive harvesting and wildfires was rapidly altered a second time following the infestation of Fraser firs by the balsam woolly adelgid (Dull et al. 1998; Smith and Nicholas 1999). A quick assessment of the age classes present in the spruce-fir ecozone indicates that 87% percent of the stands in the 51 to 60 age class originated in 1952. These stands would have likely been immature during the initial balsam woolly adelgid infestation and not susceptible to



infestation. Stand years of origin are episodic in the 1960's and 1970's when the balsam woolly adelgid was in operation, with significant young forest habitat creation in 1965, 1967, 1973, and 1977.



Mid-elevation: Red spruce dominated stands after Fraser fir mortality from BWA

The balsam woolly adelgid-associated mortality altered the structural composition of the spruce-fir ecozone dramatically. Fir mortality was highest at low elevations (Dull et al 1998). During the height of its infestation in western North Carolina (1965), mature fir mortality was estimated to be close to 2.5 million trees (Amman 1966). Fraser fir-dominated stands decreased by close to 80% between 1954 and 1988 (McManamay et al. 2010). With the exception of balsam woolly adelgid and the native insect spruce budworm (*Choristoneura fumiferana*), Fraser fir and red spruce are relatively free from damaging insects and diseases. Spruce budworm attack and defoliation are generally of greater concern in more northern portion of North America (Williams and Birdsey 2003). In addition to spruce budworm, late successional and old growth red spruce is also susceptible to several wood rotting fungi (Beck 1990; Blum 1990). Declines in overall spruce and fir growth were not observed in stands on Mt. Mitchell and Mt. Rogers due to their relatively young conditions post balsam woolly adelgid (Goelz et al. 1999). Climate models predict an increase of the suitable habitat for red spruce in certain areas of the southern Appalachian Mountains (Potter et al. 2010). Red spruce (and to a lesser degree Fraser fir) appears to hold the potential for increasing its predominance at lower elevations and in currently hardwood-dominated sites within the Nantahala and Pisgah NFs where it once may have been more abundant (Busing et al. 1992; Morin and Widmann 2010; Nowacki et al. 2010).

Age Class

<u>Current Age Class Distribution</u>

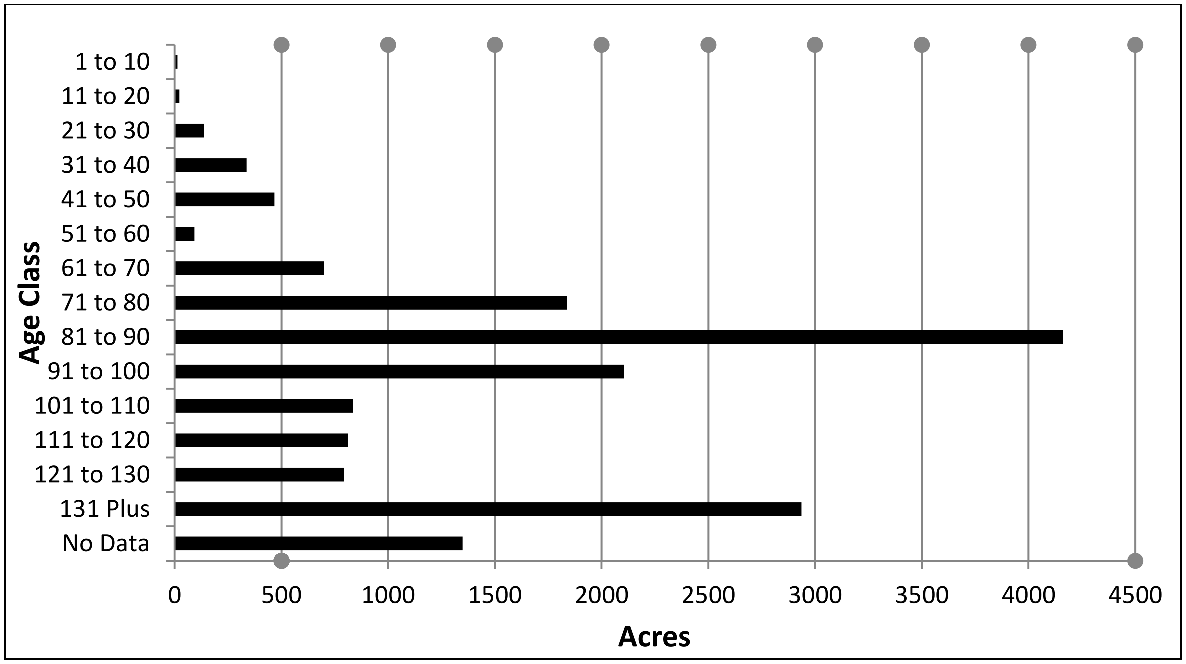
Early age classes in the spruce-fir ecozone are essentially absent for the last 20 years. The current Nantahala and Pisgah Forest Plan limits vegetation management in this ecozone. Under the current forest plan, 91% of the spruce-fir ecozone is located in designated areas.

The age classes from 61- to 100-years old are representative of regeneration following the era of exploitive logging within the spruce-fir ecozone (Brown 1941; Morin and Widmann 2010; White and Walker unpublished data). Of the acres in these age classes, over half are projected as open and slightly less than half as closed structured (based on FSVeg condition class data). The 21- to 50- year old age classes were created during higher levels of harvesting that occurred prior to the 1987 Plan. The 131-plus age class contains stands with ages as old as 253 years. The majority of these old growth stands have closed canopy conditions.

Table 9. Nantahala & Pisgah NFs spruce-fir ecozone current silvicultural age class distribution.

Silvicultural Age Class	Closed Acres (%)	Open Acres (%)	Total (%)
1 to 10	13 (0)	0 (0)	0
11 to 20	23 (0)	0 (0)	0
21 to 30	133 (1)	5 (0)	1
31 to 40	184 (1)	153 (1)	2
41 to 50	305 (2)	162 (1)	3
51 to 60	85 (1)	7 (0)	1
61 to 70	196 (1)	504 (3)	4
71 to 80	850 (5)	988 (6)	11
81 to 90	1,231 (7)	2,932 (18)	27
91 to 100	1,571 (9)	533 (3)	13
101 to 110	617 (4)	219 (1)	5
111 to 120	488 (3)	324 (2)	5
121 to 130	455 (3)	340 (2)	5
131 Plus	2,445 (15)	491 (3)	18
No Data	1,349		8
Totals	16,604		100

Figure 4. Nantahala & Pisgah NFs spruce-fir ecozone current silvicultural age class distribution.



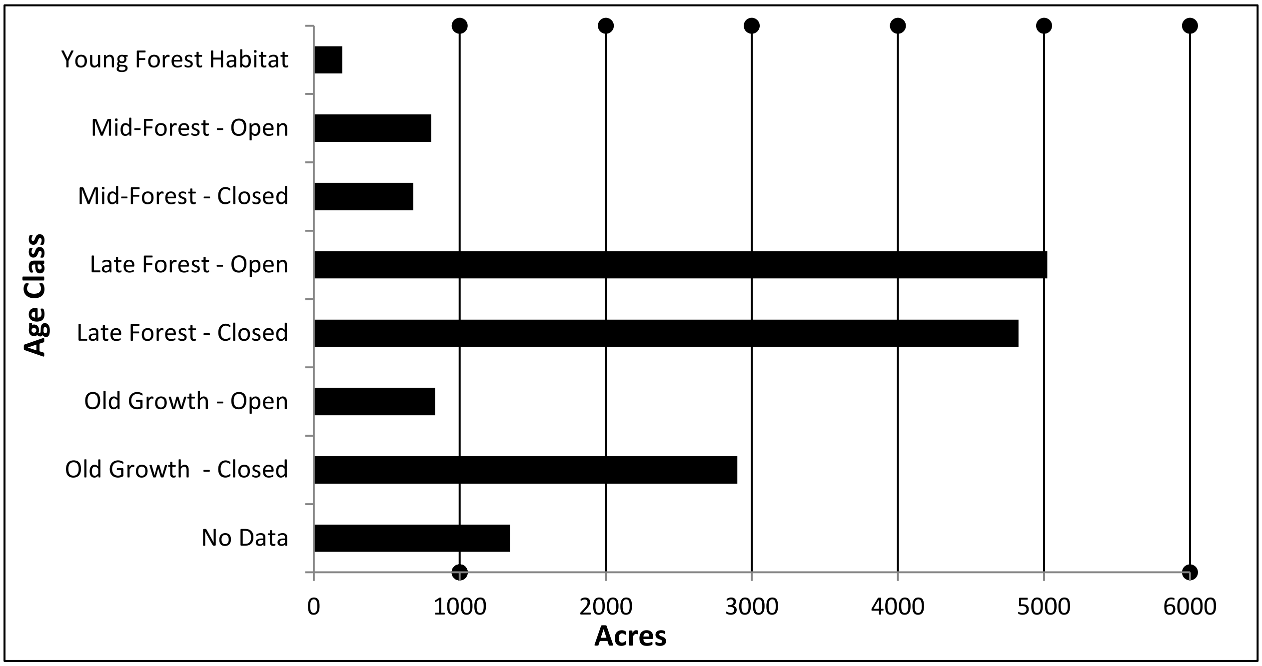
As noted in the composition section, many of the projected acres within the spruce-fir ecozone are currently occupied with other forest communities that are typically adjacent to or nearby spruce-fir. Much of the past harvesting that has occurred in the projected ecozone has occurred in these other community types.

Table 10. Nantahala & Pisgah NFs spruce-fir ecozone current BpS age class distribution[€].

Age Structure Class	Age Range	Acres	Percent of Total Ecozone
Young Forest Habitat	1 to 35	195	1
Mid-Forest Conditions - Closed	36 to 65	682	4
Mid-Forest Conditions - Open	36 to 65	805	5
Late Forest Conditions - Closed	66 to 120	4,825	29
Late Forest Conditions - Open	66 to 120	5,023	30
Old Growth Conditions - Closed	120 Plus	2,901	17
Old Growth Conditions - Open	120 Plus	831	5
Missing Data	---	1,342	8
Totals	All	16,604	100

€Open and closed determined from documented forest condition class data present in FSVeg database.

Figure 5. Nantahala & Pisgah NFs spruce-fir ecozone current BpS age class distribution.



HRV Current Age Class Distribution

The 66- to 120-year old age class contains the largest acreage (59%) in either the open or closed condition (open conditions being slightly larger). This age class corresponds to the regrowth of the majority of the Nantahala and Pisgah following the exploitive logging era. Ten percent of the spruce-fir ecozone is in young and mid forest conditions, with around 1% young forest habitat. The open habitats are more numerous in the mid and late age classes within this ecozone as they are likely recovering from the impact of balsam woolly adelgid. The converse is true of the old growth age class, which is dominated by the closed condition.

Threats and Stressors

Table 11. Threats and stressors in the spruce-fir ecozone[£].

Threat or Stressor	Species Impacted	Intensity	Duration	Component Disturbed
Balsam Woolly Adelgid	Fir	high	Long	Structure
Spruce Budworm	Spruce	low	Long	Structure
Wind	Spruce & Fir	high	Short	Structure
Ice & Snow	Spruce & Fir	high	Short	Structure
Acidic Deposition[¥]	Spruce & Fir	low	Long	Composition
Climate Change[€]	Spruce/Fir	low	Long	Composition

[¥]Atmospheric deposition of nitrogen and sulfur has been proposed to be influential in declines of the southern Appalachian spruce-fir communities (Dull et al. 1998). Research over the last 30 years has not conclusively proven it as a direct cause but expects that it is another underlying factor that predisposes the community to declines and attack (Blum 1990; Barnard and Lucier 1991).

[€]Climate Change leading to higher average annual temperatures may be a benefit to BWA (McNulty et al. 2013))

[£]Refer to the Stressors and Threats section for further information on some of the above.

Spruce-Fir Terrestrial Wildlife

Spruce-fir forests in North Carolina provide critical breeding habitat for rare birds, many of which are likely endemic to high peaks (Johns 2004; Pashley et al. 2000; Rich et al. 2004). Much of this is due to glacial recession, when species associated with spruce-fir forests became restricted to the southern Appalachians in the southeastern United States. Genetic data suggests that bird species in the central Appalachians and further north radiated from populations now restricted to the southern Blue Ridge (Hunter et al. 1999).

Many bird species that occupy spruce-fir habitats also occupy northern hardwood and high elevation red oak habitats. That is, they require habitat characteristics associated with higher elevation habitats rather than the specific structural or compositional features of spruce-fir forests. In this assessment, wildlife habitats and populations associated with northern hardwood and high elevation red oak ecozones are combined. Therefore, there is some overlap between this section and the northern hardwood/high elevation red oak section. However, spruce-fir obligate species are highlighted when possible.

Range-wide Trends

The Partners in Flight Bird Conservation Plan for the Southern Blue Ridge (hereafter, Hunter et al. 1999) identifies the red crossbill (*Loxia curvirostra*) as a bird species that is highly sensitive to the loss of spruce-fir forest. This species is dependent on spruce cone and conifer crops at high elevations for food and is associated with mid-to-late successional high elevation forests. Additionally, the northern saw-whet owl (*Aegolius acadius*), black-capped chickadee (*Poecile atricapillus*), red-breasted nuthatch (*Sitta canadensis*), brown creeper (*Certhia americana*), winter wren (*Troglodytes hiemalis*), and golden-crowned kinglet (*Regulus satrapa*) may also be affected by changes in high elevation forests.

Within the southern Blue Ridge physiographic area, populations of bird species mentioned above with the exception of the red crossbill and northern saw-whet owl have declined in areas where balsam woolly adelgid infestations caused dramatic changes in the forest's structure (Milling et al. 1997; Rabenold et al. 1998). While specific range-wide data are generally lacking for these two species, both are assumed to have declined or are at least considered vulnerable (Groth 1988; Milling et al. 1997).

Although the species discussed above are still widespread across their ranges, in the southern Blue Ridge several are represented by subspecies, are endemic, and often isolated from the larger populations in the boreal forests of northeastern North America. These birds probably represent remnants of wider ranging populations once distributed across the Southeast during the last glacial period (Hubbard 1971; Tamashiro 1996). For example, research on northern saw-whet owls identified birds from the southern Blue Ridge physiographic region as more genetically diverse than in other parts of its range, and therefore the southern Blue Ridge population may represent the ancestral form from which other populations differentiated (Tamashiro 1996; Milling et al. 1997).

Findings like these propelled most southern Appalachian endemic populations associated with high elevation forests to the top of priority lists and clearly indicate the need to investigate the genetic make-up of these species. Subspecies associated with spruce-fir forests relevant to the

Nantahala and Pisgah NFs include the southern Appalachian northern saw whet owl (*Aegolius acadicus* pop. 1), southern Appalachian red crossbill (*Loxia curvirostra* pop. 1), and the southern Appalachian black-capped chickadee (*Poecile atricapillus practica*).

Hunter et al. 1999 also prioritizes neotropical migrants associated with late successional high elevation (including spruce-fir) canopies, including the black-throated green warbler (*Setophaga virens*), and blackburnian warblers (*Setophaga fusca*), for conservation. The Canada warbler (*Wilsonia canadensis*), veery (*Catharus fuscescens*), and black-throated blue warbler (*Setophaga caerulescens*) are conservation priorities associated with high elevation (including spruce-fir) understory vegetation.

Additionally, several high-elevation bird species' ranges appear to be expanding into the southern spruce-fir zone (Hunter et al. 1999). Range-wide increases in yellow-rumped warblers (*Setophaga coronata*) and magnolia warblers (*Setophaga magnolia*) may be attributed to the maturing of spruce-fir forests while higher occurrences of Swainson's thrush (*Catharus ustulatus*) and hermit thrush (*Catharus guttatus*) may be a response to understory development in spruce-fir.

Populations of understory and early successional species like black-throated blue, Canada, and chestnut-sided warblers (*Setophaga pennsylvanica*), and eastern towhee (*Pipilo erythrophthalmus*) have been stable or increasing in areas where spruce remains in high densities, but fir has declined (Rabenold et al. 1998), though species are generally declining range-wide (USGS 2013). Additionally, canopy species such as blackburnian and black-throated green warblers (although relatively common) seem to be declining (USGS 2013).

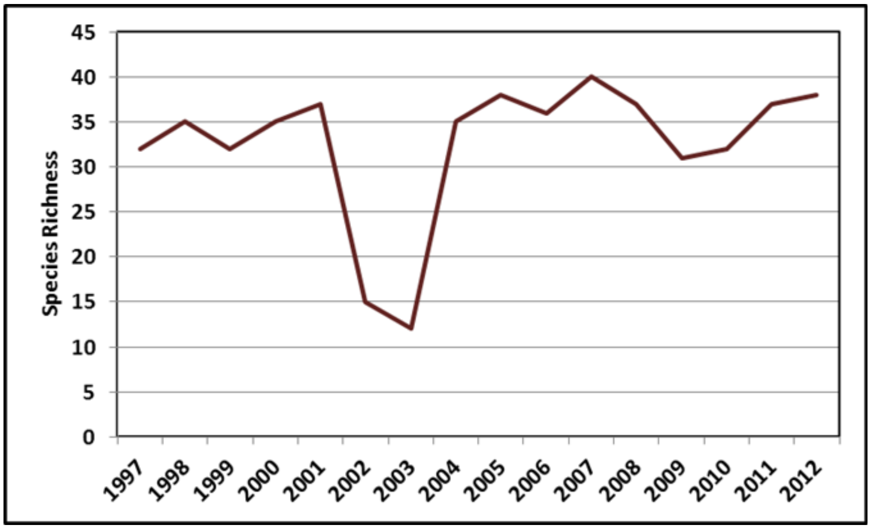
Ultimately, Hunter et al. (1999) identifies the northern saw-whet owl and black-capped chickadee as the most vulnerable, and therefore the best species for determining restoration goals for high elevation forests, including spruce-fir. Furthermore, of these species, black-capped chickadee appears to be the most susceptible to extirpation from habitat deterioration and the least likely species to become reestablished in areas that have recovered (Rabenold et al. 1998). Because spruce-fir habitats are vulnerable to the stresses of the balsam woolly adelgid and climate change, these species are particularly susceptible.

Red crossbill should also be considered highly vulnerable, but using this species as a representative may be difficult because of confusing taxonomy (Groth 1988) and erratic occurrence at any one location. Brown creeper is also a good representative, but its association with peeling loose bark and trees with large diameters makes this species better suited for defining habitat condition rather than setting spatial restoration goals.

Forest-Level Trends

Sixty-nine bird species have been documented in spruce-fir forests in the Nantahala and Pisgah NFs between 1997 and 2012 (Appendix A, USFS 2013). Within this same monitoring period, species richness within spruce-fir forests has increased slightly, except during 2002 and 2003, when only 25% of the spruce-fir sites were monitored (Figure 6).

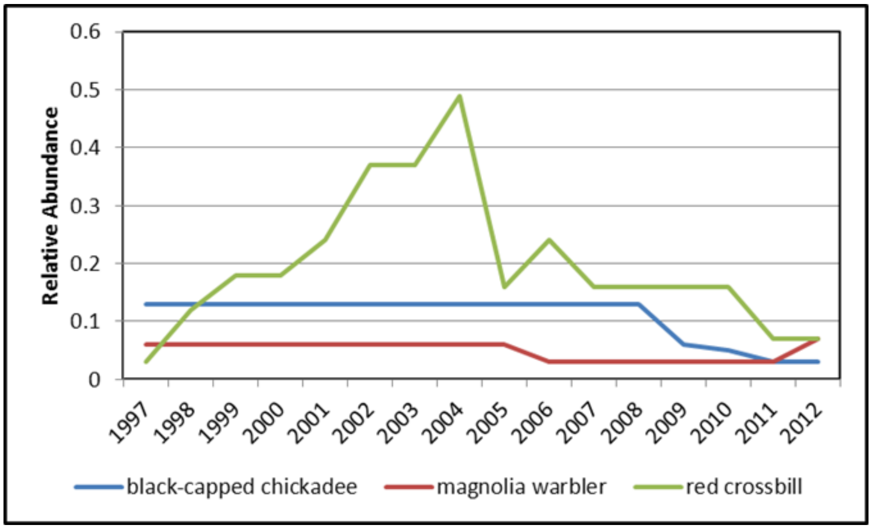
Figure 6. Landbird species richness within spruce-fir forests on the Nantahala and Pisgah NFs, 1997-2012 (USFS 2013).



Long-term monitoring data (USFS 2013) includes four priority bird species identified in the 2005 North Carolina Wildlife Action Plan (NCWAP) (NCWRC 2005) that are associated with spruce-fir forests that occur at low densities. These species include the sharp-shinned hawk (*Accipiter striatus*), magnolia warbler, black-capped chickadee, and southern Appalachian red crossbill (*Loxia curvirostra* pop. 1). Sharp-shinned hawks are uncommon on the Nantahala and Pisgah NFs—numbers are so low that they cannot be accurately displayed with other species. Also, black-capped chickadee hybridization with the Carolina chickadee (*Poecile carolinensis*) often makes identification difficult and may compromise data analysis - this analysis uses only records positively identified as *P. atricapillus*.

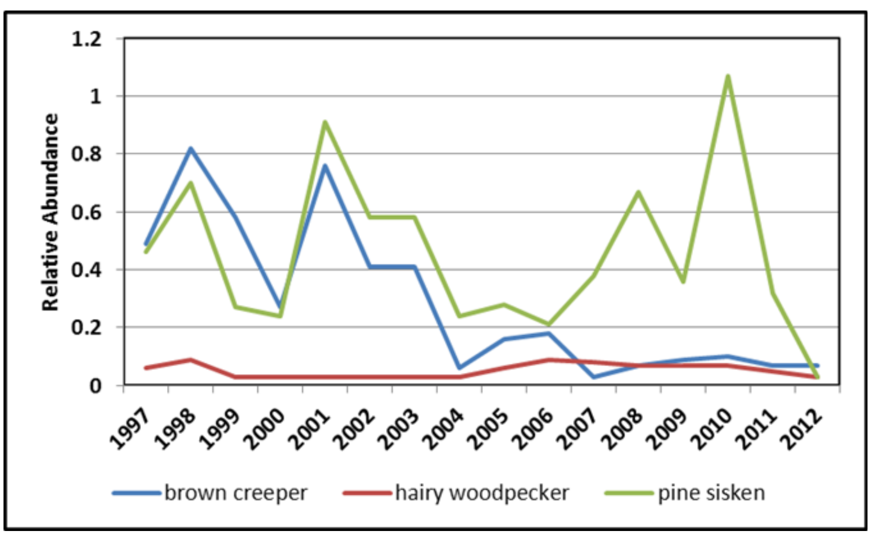
Population trends of magnolia warblers and black-capped chickadees are stable to slightly declining within spruce-fir habitats. Red crossbill populations are also decreasing and exhibit higher variability over the sixteen-year monitoring period (Figure 7).

Figure 7. Relative abundance of bird species that occur at naturally-low densities associated with spruce-fir forests, 1997 through 2012 (USFS 2013).



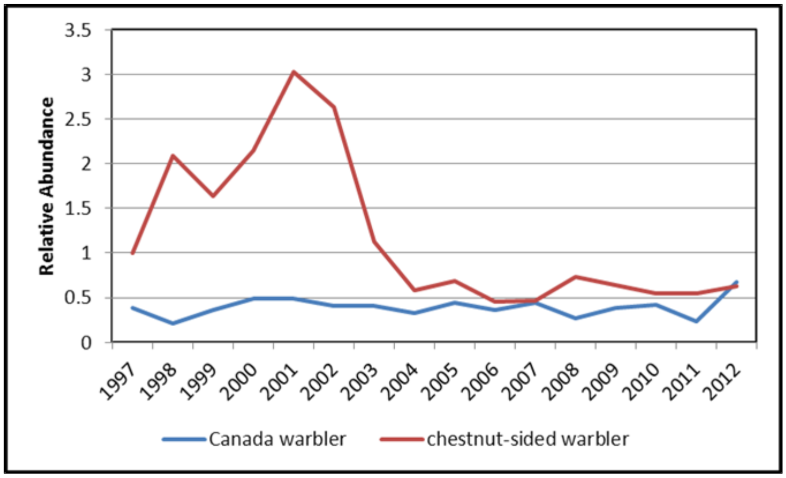
Additionally, long-term monitoring data (USFS 2013) includes three NC Wildlife Action Plan priority bird species occurring at moderate densities associated with spruce-fir forests. These species include the hairy woodpecker (*Picoides villosus*), brown creeper, and pine siskin (*Carduelis pinus*). Population trends of hairy woodpecker and pine siskin demonstrate slightly decreasing trends within spruce-fir forests and across the Nantahala and Pisgah NFs over the sixteen-year monitoring period, although high annual variability is evident. Brown creeper populations show sharply decreasing trends within spruce-fir habitats during the same monitoring period (Figure 8).

Figure 8. Relative abundance of bird species that occur at moderate densities associated with spruce-fir forests, 1997 through 2012 (USFS 2013).



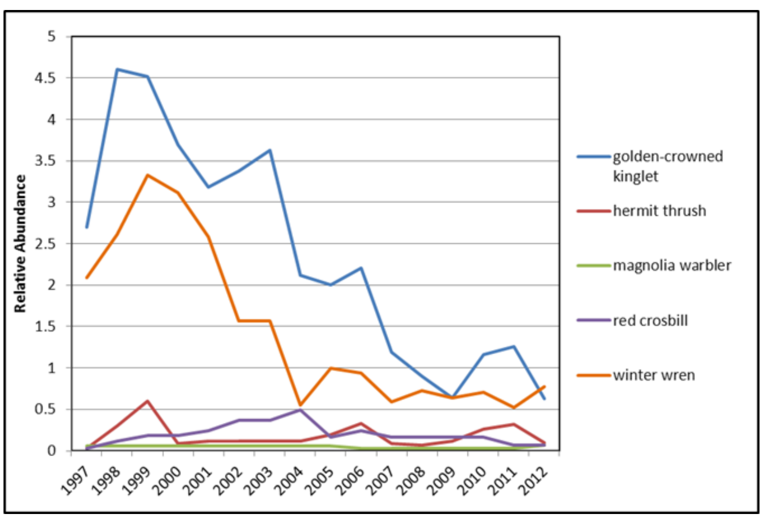
Long-term monitoring data (USFS 2013) includes two NC Wildlife Action Plan priority bird species occurring at higher densities associated with spruce-fir forests. These species include the Canada warbler and chestnut-sided warbler. Population trends of Canada warblers have been stable to slightly increasing within spruce-fir habitats over the sixteen-year monitoring period, while chestnut-sided warbler populations appear to have decreased substantially since 1997 (Figure 9). This decrease is likely due to the loss of early successional habitat characteristics at high elevations, including spruce-fir, forests.

Figure 9. Relative abundance of bird species that occur at higher densities associated with spruce-fir forests, 1997 through 2012 (USFS 2013).



Perhaps most indicative of bird population trends within spruce-fir forests are those of species that are spruce-fir obligates (or near-obligates). These species include the red crossbill, winter wren, hermit thrush, magnolia warbler, and golden-crowned kinglet. Within spruce-fir habitats on the Nantahala and Pisgah NFs, populations of magnolia warbler, hermit thrush, and red crossbill are relatively stable (however, low in numbers), whereas winter wren and golden-crowned kinglet populations have decreased sharply and demonstrate higher annual variability (Figure 10).

Figure 10. Relative abundance of bird species considered to be spruce-fir obligates, or near-obligates within spruce-fir forests, 1997 through 2012 (USFS 2013).

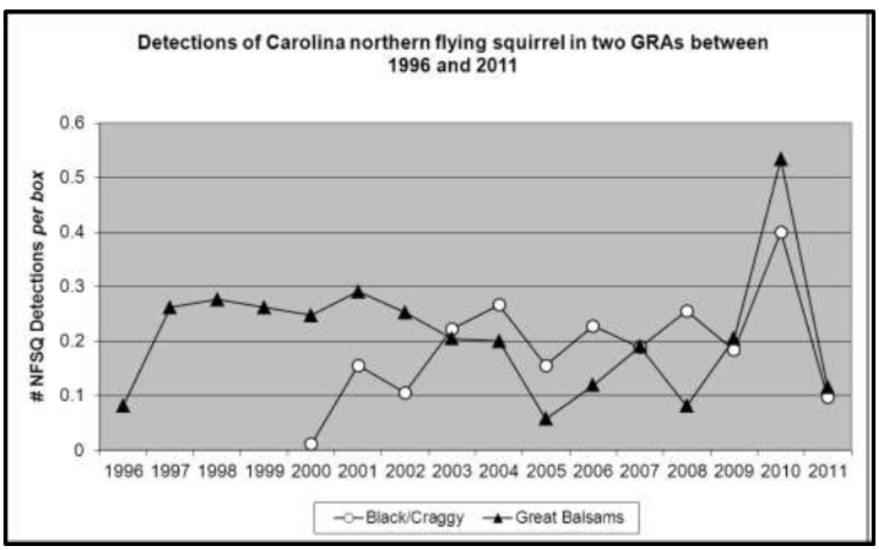


Generally speaking, bird populations within spruce-fir forests are stable to sharply decreasing. Wildlife habitat quality (and therefore wildlife populations) within this ecozone is susceptible to stresses such as the balsam woolly adelgid, acid deposition, ice damage and windthrow, and climate change. These factors, along with less vegetation management and infrequent fire disturbance, affect structural composition and therefore habitat diversity, which is reflected in bird population trends.

Spruce-fir forests provide essential habitat for several animal species found nowhere else in North Carolina, including the federally endangered Carolina northern flying squirrel (*Glaucomys sabrinus coloratus*), spruce-fir moss spider (*Microhexura monitvaga*), northern pigmy salamander (*Plethodon organi*), and Weller's salamander (*P. welleri*). As a result of the stresses and threats discussed above, local relative abundance of these and other species are vulnerable. Additionally, the fact that these habitats are so small and isolated from each other could have a negative impact upon genetic health of individual populations, as well as demographic effects upon populations. These four species depend exclusively, or in large part, on the unique characteristics of spruce-fir forests.

Although acoustic monitoring began recently, Carolina northern flying squirrel populations are monitored primarily through nest box detections. Two areas which are monitored intensively include the Black and Craggy Mountains and the Great Balsam Mountains. In the Great Balsam Mountains, nest box detections have remained relatively stable since 1996, although annual variability has increased since 2004. Within the Black and Craggy Mountains, nest box detections have increased slightly since 2000 (Figure 11).

Figure 11. Number of Carolina northern flying squirrel detections per nest box within the Black and Craggy Mountains and the Great Balsam Mountains, 1996 through 2011 (NCWRC 2012).



No long-term monitoring data exists for the spruce-fir moss spider. However, recent inventories have expanded the known range of this species to include spruce-fir habitats.

No long-term monitoring data exists for the northern pigmy and Weller's salamanders. However, recent inventories have expanded the known range of these species to include spruce-fir habitats.

Northern Hardwood Ecological Zone

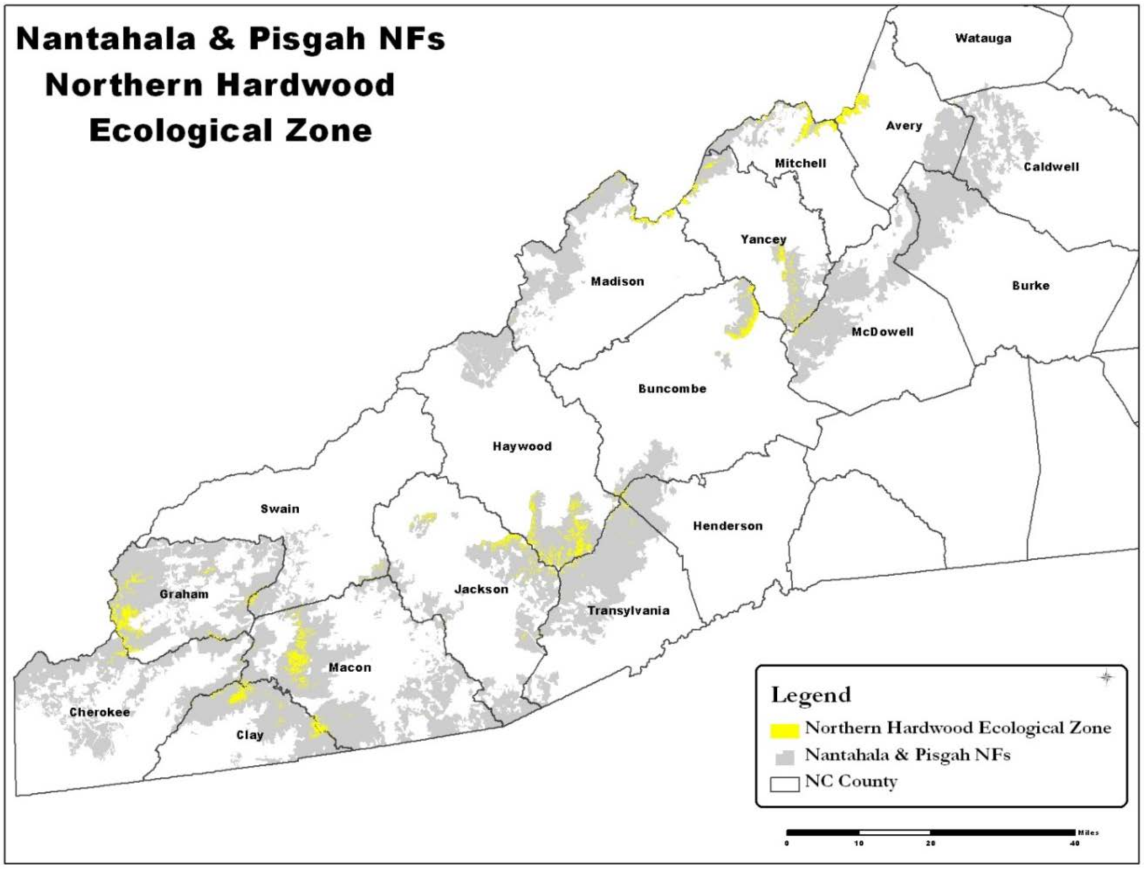
Environmental Setting: The northern hardwood ecological zone is typically found above 4,000 feet elevation, and occurs up to 5,500 feet elevation. This zone three subtypes: rich cove, acidic cove, and typic. Rich and an acidic subtypes occur on protected moist toe slopes and narrow to broad concave drainages (Simon 2011). The typic subtype occurs on steep slopes, often convex in shape. Soil moisture is generally not limiting within this zone, although can be quite variable across the three subtypes considering the different landscape positions. Soil pH can be variable, as low as 4.3 with low base content, to much higher in areas influenced by mafic rock, where the rich cove subtype tends to occur (Natureserve 2013; Carolina Vegetation Survey 2013). Low temperatures, hoar frost, and ice storms are all important natural disturbance events influencing this zone.

Geographic Distribution: The northern hardwood ecozone covers approximately 5.2%, or 54,000 acres, of the Nantahala and Pisgah NFs. On non-national forest lands in the surrounding 18-county area, the ecozone covers approximately 3% of the land base. This narrow ecozone ranges from the southern West Virginia and south-central Virginia mountains to western North Carolina, eastern Tennessee, and a small area of northern Georgia (Natureserve 2013). The rich and acidic cove subtypes occurs across a slightly broader range from West Virginia to Georgia, while the typic subtype is not known to extend into Georgia (Natureserve 2013). All three of these subtypes are considered globally vulnerable either with a G3 or a G3G4 rank (Natureserve 2013).

In western North Carolina, the northern hardwood ecozone is patchy but relatively evenly distributed occurring at greater than 4,000 feet elevation with concentrations across the Unicoi Mountains, Smoky Mountains, Chunky Gal Mountain, Nantahala Mountains, Balsam Mountains, Black Mountains, Bald Mountain, Grandfather Mountain, and Roan Mountain. It is less common across the Blue Ridge Escarpment.

Based on LiDAR analysis of shrub density, a more open understory with less than 50% shrub coverage extends across approximately 60% of the ecozone. This open portion would represent the rich subtype and portions of the typic subtype. All three subtypes are evenly distributed across the two forests; however the rich and acidic subtypes are typically smaller in patch size when compared with the typic subtype.

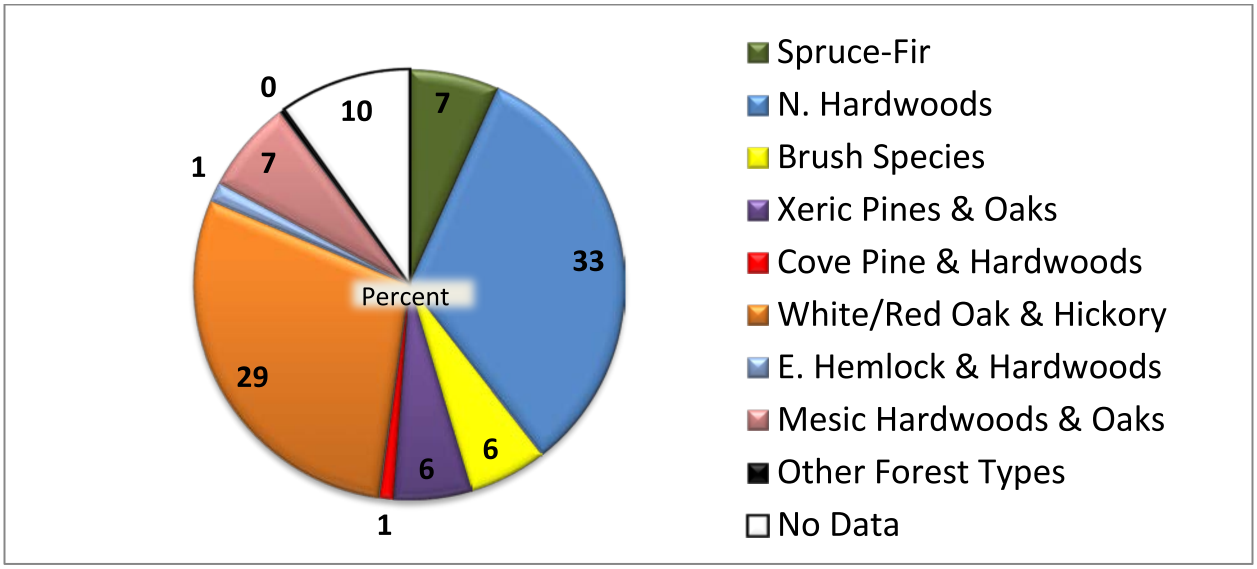
Figure 12. Distribution of northern hardwood ecological zones across the Nantahala and Pisgah NFs.



FSVeg Types

Within Nantahala and Pisgah NF lands, the vegetation management database identifies 17,452 acres as having components of the northern hardwood community. These acres represent approximately 36% of the northern hardwood ecozone (Figure 13). Another 63% of the acres within the ecozone are identified as forest communities typically adjacent to or in close proximity to the northern hardwood community on the landscape. The largest of these are the Oak Hickory types (29%). Other common associates like spruce-fir occupy lower percentages of the ecozone.

Figure 13. Nantahala & Pisgah FSVeg forest type breakdown within the northern hardwood ecozone.



Composition

The northern hardwood forest is dominated by closed canopy yellow birch (*Betula allegheniensis*), sugar maple (*Acer saccharum*), yellow buckeye (*Aesculus flava*), or beech (*Fagus grandifolia*) for the rich subtype. The typic subtype tends to be more dominated by yellow birch and beech. Red oak (*Quercus rubra*) becomes more prevalent within this subtype as well. The northern hardwood rich subtype generally has an open understory while the typic subtype can be open to having a moderately dense shrub layer, which is often dominated by deciduous shrubs or small trees. In contrast the acidic subtype typically has a tall (over 2 meters in height), dense (from 50-100% cover), shrub layer dominated by great laurel and doghobble (*Leucothoe fontansiana*). Shrubs within the other two subtypes include hobblebush (*Viburnum lantanoides*), red elderberry (*Sambucus racemosa* var. pubens), mountain holly (*Ilex montana*), serviceberry (*Amelanchier laevis*), blueberry (*Vaccinium corymbosum*), and striped maple (*Acer pensylvanicum*). Herbaceous diversity is sparse under the densest shrub layer and would account for those sites recorded with only 14 vascular plant species (Ulrey 1999).

The northern hardwood typic subtype is typically dominated by Pennsylvania sedge (*Carex pensylvanica*) and white snakeroot within the herb layer. Herbaceous diversity is much greater in the rich subtype. Some of the more abundant and distinctive herbaceous species include blue cohosh (*Caulophyllum thalictroides*), yellow cohosh (*Actaea podocarpa*), Blue Ridge white heart-leaved aster (*Eurybia chlorolepis*), false nettle (*Laportea canadensis*), Tennessee chickweed (*Stellaria corei*), Carolina spring-beauty (*Claytonia caroliniana*), and stinking willie (*Trillium erectum*). This subtype provides the greatest densities for ramps (*Allium tricoccum*) across the Nantahala and Pisgah NFs. In the richer areas, vascular plant species diversity can exceed 80 species. As within spruce-fir forest, epiphytic bryophyte diversity (mosses and liverwort), is high within the most mesic portion of this ecozone.

Connectedness

The cove subtypes often intergrade into the slope type which often intergrades to high elevation red oak forest on steep upper slopes, and even exposed convex slopes. On lower slopes within the drains, the type grades into rich cove or acidic cove forest. Given the numerous herbs that occur within both rich cove and northern hardwood forest, this gradation can be quite subtle and extend across a large area (Schafale and Weakley 1990). Rare habitats embedded or adjacent to this zone include high elevation seeps, boulderfields, beech gaps, heath balds, and grassy balds.

Northern hardwood forest can occur as fragmented patches within western North Carolina. Even though the patches are distributed across the Nantahala and Pisgah NFs, there can be a separation of 13-25 aerial miles between concentrated occurrences across both public and private lands. There are no obligate northern hardwood plant species, rather most species occurring there are facultative high elevation species. As such, most species would be more affected by gaps in high elevation habitat which are typically separated by six aerial miles or less, except for one large gap spanning the Asheville basin for 17-22 aerial miles. For certain species such as Gray's lily, currently impacted by a fungus, the patchiness could result in impacts on its long-term viability. The same may be true for ramps since they have been harvested for the plant's edible roots for centuries. Given the juxtaposition of the slope and cove types in the same landscape, a few concentrated areas have northern hardwood patch sizes up to 350 acres. More typical patch sizes range from 30-60 acres.

Designated Areas

About 50% of the northern hardwood ecozone is currently within existing designated areas. Those acres within the designated areas are dispersed across the two forests although sparse within the Big Ivy area, the Nantahala Mountains, and the Santeetlah Creek drainage.

Disturbance Dynamics

Canopy gaps and openings are generally driven by wind events and ice storms, although eastern hemlock dieback from hemlock woolly adelgid may have recently increased the number of openings. Patch sizes can vary from single trees to numerous trees, particular with the recent impacts to eastern hemlock. Historically this zone was only subject to occasional fires (Konopik 2005). Surface fires are considered rare with a greater than 1,000 year fire return frequency (Landfire 2009). Typically the cove portion of the zone is moist enough to extinguish fires originating from the uplands. In contrast, catastrophic fires can be more frequent, at a 300 to 1000 year interval, typically occurring following a large scale wind event followed by an historic drought. Fire suppression following the mid-1900s may have expanded the northern hardoow community, in particular the drier typic subtype, to the detriment of adjacent high elevation red oak forest (C. Frost, fire regime consultant, personal communication, 1999). An emphasis on larger landscape burns during the last seven years across the Nantahala and Pisgah NFs has resulted in 1,439 acres of burns within the northern hardwood ecozone.

Non-Native Invasive Plant Species

Compared to other mesic ecozones, few invasive non-native plant species have been located within northern hardwood, probably due to higher elevations and relatively infrequent disturbances. Garlic mustard and oriental bittersweet are two species that have been located within closed canopy northern hardwood forest based on USFS inventories in the Nantahala & Pisgah NFs. The risk to this ecozone from non-native invasive plant species increases with impacts to the overstory from human or natural disturbances. Up to twelve of the most invasive plants have been recorded across this zone in open sites. The concave portions of this ecozone pose the greatest risk of invasion within this ecozone.

Northern Hardwood Vegetation Structure

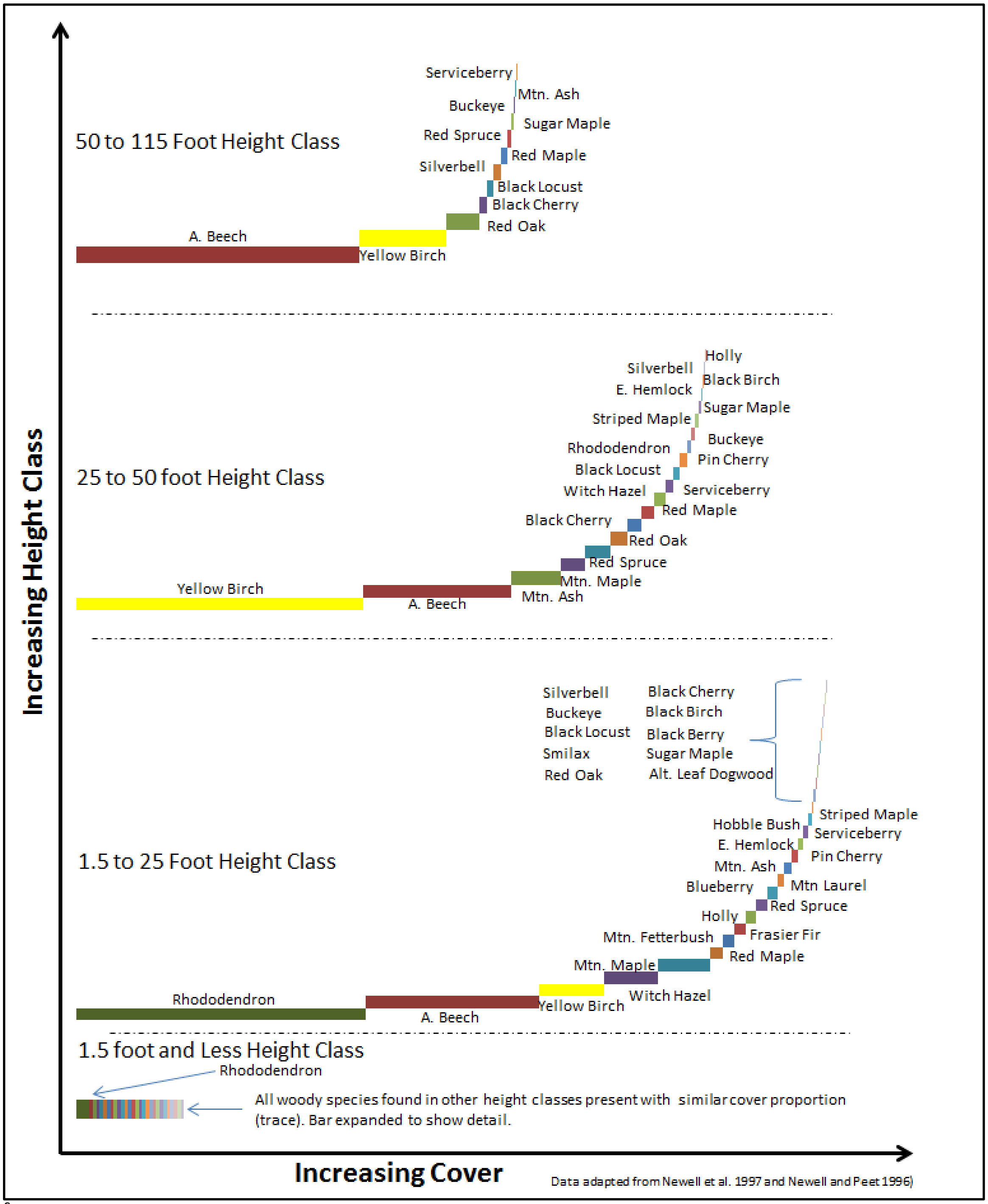
Within the northern hardwood ecozone, community structure may differ dramatically between those sites dominated by American beech and those dominated by yellow birch, sugar maple, and buckeye (White et al. 1993). With ice and wind the most common disturbances and widespread fire infrequent (PIF 1999), the overstory trees are often stunted or have poor form (White et al. 1993). Vegetation surveys and research including wilderness areas within the Nantahala and Pisgah NFs have identified several different community types (Ramseur 1960; White et al. 1993; Newell and Peet 1996; Newell et al. 1997).

Yellow birch, red maple and fire cherry communities may represent post logging and fire successional stages that will become increasingly dominated by beech and sugar maple (Ramseur 1960; White et al. 1993). Figure 14 may display an example of such a successional trend. Evidence of fire was reported in many birch dominated stands (Newell and Peet 1996; Newell et al. 1997) though overall this community is typically not disturbed by fire in most locations where it is found (Schafale and Weakley 1990).

For communities dominated by yellow birch, the main canopy was 65 to 72 feet high with large diameter birch (17 -27 in). American beech filled the rest of the canopy. Rhododendron and vaccinium are major parts of the shrub layer that is between 10 and 16 feet tall (Figure 14, Table 13) (Newell et al. 1997). The shrub layer can range from dense to patchy (PIF 1999) with a corresponding response from the understory plant communities (Table 14). On more mesic sites maple species and buckeye play a larger role in structure with rhododendron understories (Schafale and Weakley 1990; Newell and Peet 1996). Openings tend to be dominated by blackberry (Newell and Peet 1996).

Betula-dominated communities still contain a lot of *A. beech* supporting the theory that these communities transition to shade tolerant species over time (Figure 14, Table 13). This type of transition may be more rapid under the influence of beech bark disease (BBD) and nitrogen deposition which accelerates infestation of *A. beech* by the adelgid and subsequent mortality (Latty 2005). Birch is the most dominant in the middle height classes where *A. beech* is not present in enough abundance to take over. As mentioned above the presence of BBD may put birch-dominated communities under structural change (Table 13). Rhododendron and other ericaceous shrubs have the potential to dominate conditions in the northern hardwood understory especially with its less frequent fire regime and typically more moist conditions. As with the composite FIA data (Figure 14), many species of other ecozones are present in low abundance throughout the ecozone representing the breadth of the ecozone between northern hardwoods and the adjacent communities. This broad transition is more apparent in birch-dominated communities which normally have better understory light conditions than those dominated by *A. beech* through several layers of the canopy.

Figure 14. National forests in North Carolina northern hardwood ecozone structure and cover representation based on surveys of birch dominated communities in Shining Rock and the Joyce Kilmer/ Slickrock Wildernesses£.



£*Species cover is proportional to each other within each height class as well as between height classes. Overall height class cover is relative to other height classes with the exception of the 1.5 foot and less class, which is expanded for detail. Total cover does not equate to 100%. There were no species reported to have heights greater than 115 feet.*

Red spruce and fir are also scattered components within these communities, increasing structural diversity and providing important winter habitat conditions (Figures 14 & 15) (Newell and Peet 1996; NCWRC 2005). It is suspected that many sites dominated by birch species were once spruce-fir forest that succumbed to logging and/or intense fire (Ramseur 1960; Schafale and Weakley 1990; Newell and Peet 1996) and may become more rich in structure and composition as spruce regains a foothold (Busing et al. 1992; NCWRC 2005; Morin and Widmann 2010; Nowacki et al. 2010). Fire is a variable feature on mesic sites but may be more important on exposed drier sites.

For communities dominated by American beech, the canopy may vary depending on the location of the community on the landscape. American beech has been found to dominate all aspects of the understory and overstory occupying 75% of the saplings and 99% of the trees greater than one inch in diameter. In more sheltered, mesic sites the main canopy may still contain scattered large diameter yellow birch (18 to 34 in dbh) with canopy heights of 75 feet. Certain sites contain sugar maple in the lower portions of the canopy with a shrub layer containing American beech 7 to 13 feet tall (Newell et al. 1997) or absent (SAMAB 1996). The ground layer is commonly dense with herbaceous species (SAMAB 1996). More mesic sites have a greater degree of sugar maple (and buckeye) as part of the stand structure. These two species may occupy 50% or more of the stems greater than 16 inches DBH (Newell and Peet 1996).

On more exposed sites, beech may dominate with scattered birch and oak up to 65 feet tall. Beech importance values may be between 40 and 83 (*100 basis*) (White et al. 1993). Beech gap canopies are often described as being stunted in height, higher in stem density, and small in stem size (Table 13) (Newell and Peet 1996; SAMAB 1996). The sub-canopies are also dominated by beech typically 5 to 7 feet tall (Newell et al. 1997). Understories may be open (Newell and Peet 1996), a condition accentuated and perpetuated by BBD, which causes a “beech hell” of very dense small stems (Cogbill 2005). BBD-infested stems have a dramatically increased susceptibility to wind and ice damage (Houston and O’Brien 1983; Latty 2005; Papaik et al. 2005) and given the large proportion of beech in gaps and their location on the landscape atmospheric disturbances have the potential to dramatically (and rapidly) change the structure of these communities. Beech-dominated communities may represent a later successional stage due to the tree’s shade tolerance in the absence of disturbance. Beech gaps seem particularly capable of self-perpetuation in the face of beech bark disease though the average tree size may be reduced (Table 13).

Ramseur (1960) found Beech gaps dominated by beech trees up to 14 inches DBH with scattered Buckeye (5%) in the canopy (similar to Table 13). He also identified other beech gaps that contained trees of smaller diameters. Beech suckers and sprouts were common as well as a few spruce seedlings. Shrubs are rare and herbaceous species are abundant. There is an abrupt structural and compositional transition between beech gaps and the surrounding forests (Ramseur 1960). Conversely, the transition to other birch-dominated northern hardwood communities is very hard to discern (Schafale and Weakley 1990).

LiDAR data gathered across the Nantahala and Pisgah in 2005 supports the variable density of the shrub layer within the northern hardwood ecozone (Table 14). The relative heights of the main canopy within both birch-dominated and American beech-dominated communities noted within the literature also coincide well with the available LiDAR data. Greater than 40 percent of the ownership within this ecozone has canopy heights between 51 and 75 feet (Table 15). This is larger than any other height class.

Table 12. Structural characteristics comparisons between birch-dominated northern hardwoods and beech gaps detailing their different structures (Newell et al. 1997, Newell and Peet 1996).

	Saplings (ft2/ac)	**Trees (ft2/ac)**	**Large Trees (ft2/ac)**	**Basal Area (ft2/ac)**	**Relative Density (%)**
Beech Gap Community					
Total Area	296	2,440	3	155	100
Percent *A. Beech*	75	99	50	95	96
Percent *Y. Birch*	---------------------none ---------------------				
Composite Birch Dominated Community					
Total Area	2,494	1647	12	126	82
Average % *A. Beech*	35	17	5	14	23
Average % *Y. Birch*	1	18	76	42	18

Table 13. LiDAR-derived shrub density classes for the northern hardwood ecozone and the percentage of ownership within each class (0 to 15 feet tall).

Cover Class (%)	**0 to 25%**	**26 to 50%**	**50 to 75%**	**76 to 100%**
Nantahala & Pisgah	27%	34%	24%	15%
Non-National Forest	34%	34%	21%	11%

Table 14. LiDAR-derived canopy height classes for the northern hardwood ecozone and the percentage of ownership within each class.

Height Class (ft)	**1 to 10**	**11 to 20**	**21 to 30**	**31 to 50**	**51 to 75**	**76 to 100**	**100+**
Nantahala & Pisgah	2%	2%	4%	18%	44%	26%	3%
Non-National Forest	5%	2%	3%	14%	41%	31%	4%

Figure 15. Composite FIA Data representing abundance and dominance of tree species/groups for the northern hardwood ecozones in the Stem Exclusion (A) and Understory Reinitiation (B) phases.

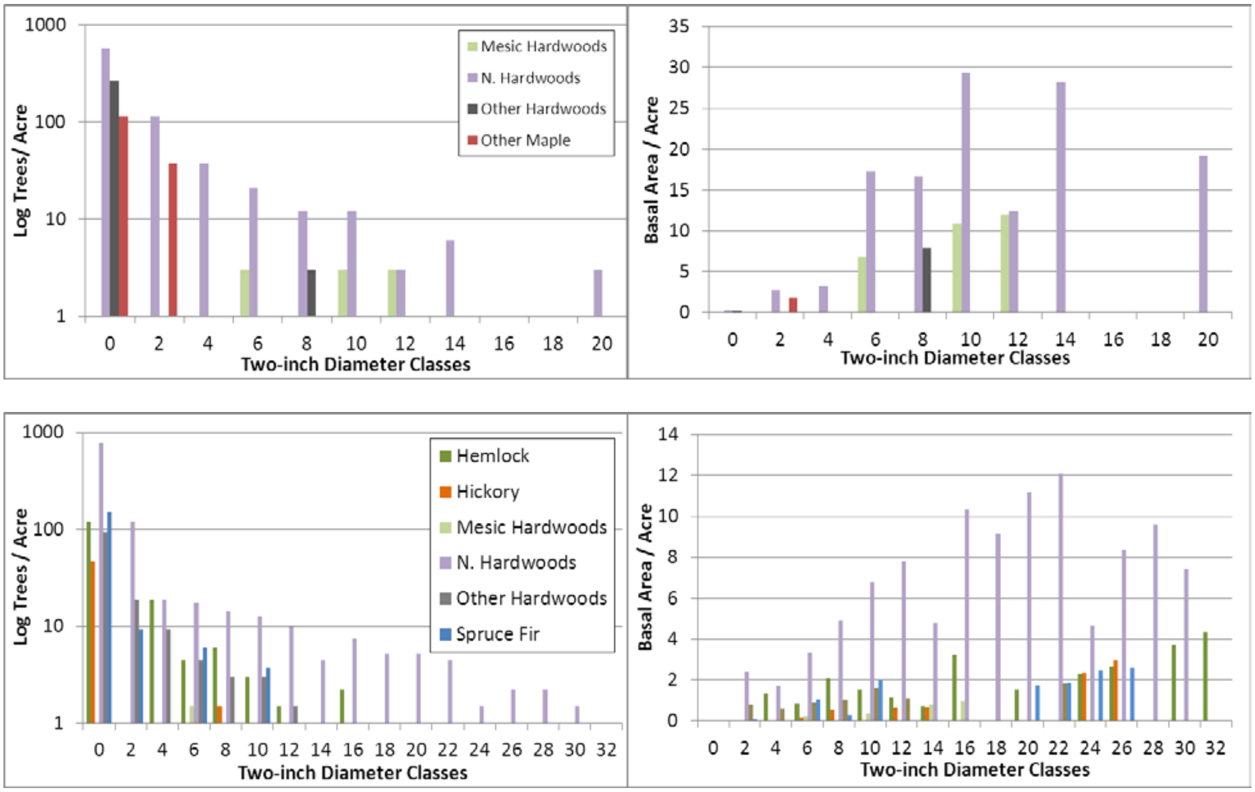
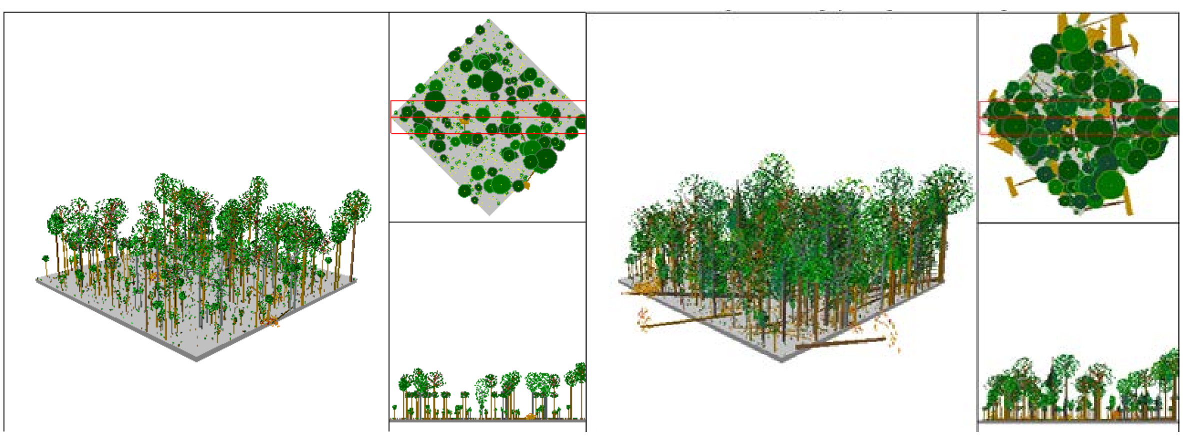


Figure 16. View of composite FIA data taken within the northern hardwood ecozone during at the end stem exclusion stage (left). View of composite FIA data taken within the northern hardwood ecozone during the understory (right).



Composite FIA data (Figure 15) shows northern hardwood species high in abundance and dominance in both maturing forest and mature forest conditions. These presence of these communities in the landscape contributes to the hardwood species' dominance. Yellow birch is easily established after disturbance and *A. beech* and sugar maple persist as small trees after disturbance allowing them to increasingly control a site over time. Other species are present in low abundance and dominance due to the northern hardwoods having a larger ecozone (transition) separating them from other communities.

Age Class

Current Age Class Distributions

Intense harvesting commenced in the late 1800s in the northern portions of the range and proceeded south to the Smokies where it stopped in 1926 with the development of the park (White et al. 1993). Thus, the 81-90 year age class that grew up following that era has the greatest percentage of stands (Table 16 and Figure 18). Both very young and very old forests have very little representation in the current condition of the ecozone.

Table 15. Nantahala and Pisgah NFs northern hardwood silvicultural age class distribution.

Silvicultural	Closed	Open	Total
Age Class	Acres (%)	Acres (%)	Acres (%)
1 to 10	63 (0)	0 (0)	63 (0)
11 to 20	206 (0)	0 (0)	206 (0)
21 to 30	1,283 (2)	99 (0)	1,382 (3)
31 to 40	532 (1)	360 (1)	892 (2)
41 to 50	1,179 (2)	47 (0)	1,227 (2)
51 to 60	1,037 (2)	22 (0)	1,059 (2)
61 to 70	1,345 (2)	656 (1)	2,001 (3)
71 to 80	4,376 (8)	964 (2)	5,341 (10)
81 to 90	4,976 (9)	5,198 (10)	10,174 (19)
91 to 100	4,278 (8)	1,686 (3)	5,964 (11)
101 to 110	3,141 (6)	1,977 (4)	5,118 (10)
111 to 120	1,608 (3)	1,786 (3)	3,394 (6)
121 to 130	1,954 (4)	2,148 (4)	4,103 (8)
131 to 150	2,208 (4)	1,911 (4)	4,120 (8)
151 to 200	926 (2)	855 (2)	1,780 (4)
200 Plus	40 (0)	21 (0)	61 (0)
No Data	5,993 (11)		
Total	53,922 (100)		

Open and closed conditions are equal for communities greater than 111 years old. They represent 26% of the ecozone when combined. Open canopied overstory conditions may be on the rise with the spread of BBD. Earlier age classes are typically more closed than open also related to the presence of *A. beech* being affected by BBD. Alternatively rhododendron and shade tolerant species may be present furthering the closed conditions, except in the 81 to 90 year old class, which has roughly equal canopy density conditions.

Mid-forest open conditions are only lightly represented on the landscape (Table 17 and Figure 17). Mature forest conditions dominate the landscape with somewhat more in a closed canopy condition than in open canopy (Table 17). Young forest habitat is the least available in the ecozone.The predominance of closed conditions is expected under a typical disturbance regime that has a longer fire return interval. Ice, snow, and wind do disturb the main canopy creating some young forest habitat and open conditions, but a fire eventwould take a greater toll on the mid-story and understory.

Old growth conditions represent 11 percent of the ecozone. The northern hardwood ecozone also has the distinction of the largest area without available data owing to its limited management under the current forest plan.

Table 16. Nantahala and Pisgah NFs northern hardwood ecozone current BpS age structure class conditions.

Age Structure Class	Age Range	RC Acres (%)
Young Forest Habitat	1 to 24	843 (2)
Mid-Forest Conditions - Closed	25 to 75	6,987 (13)
Mid-Forest Conditions - Open	25 to 75	1,682 (3)
Mature Forest Conditions - Closed	76 to 130	18,249 (34)
Mature Forest Conditions - Open	76 to 130	13,163 (24)
Old Growth Conditions - Closed	131+	3,174 (6)
Old Growth Conditions - Open	131+	2,787 (5)
No Data	---	7,037 (13)
Totals	All	53,922 (100)

Figure 17. Nantahala and Pisgah NFs northern hardwood current BpS age structure class conditions.

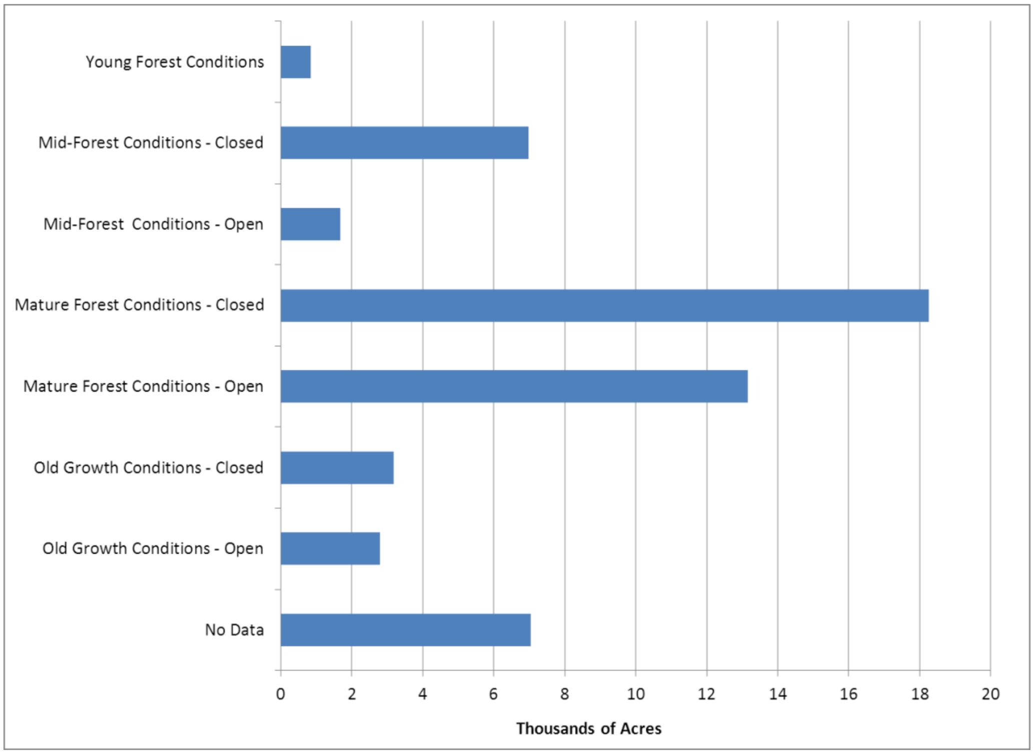
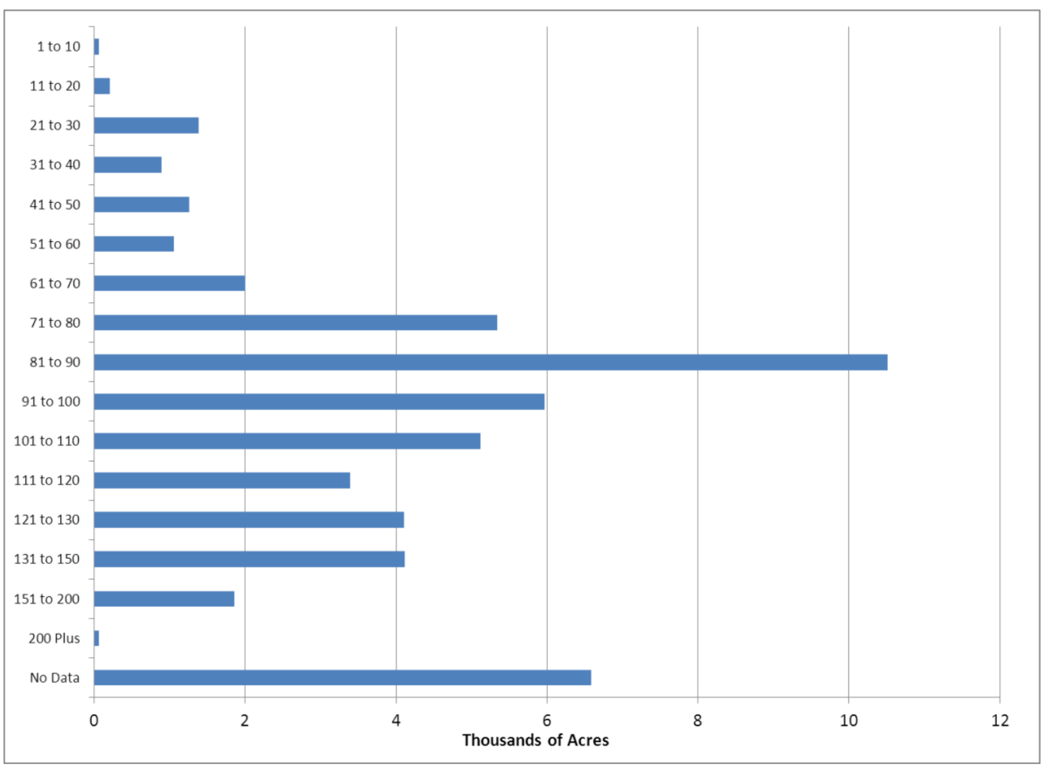


Figure 17. Nantahala & Pisgah NFs northern hardwood current silvicultural age class distribution.



Northern Hardwood and High Elevation Oak Terrestrial Wildlife

Northern hardwood forests provide habitat for numerous wildlife species that also rely heavily on neighboring spruce-fir forests. Because of the spatial relationship between them, and the fact that they share many ecological components and plant species, northern hardwood forests are critical to maintaining many species of birds and mammals dependent upon spruce-fir habitats (reference the Spruce-Fir Terrestrial Wildlife section of this document). Additionally, northern hardwood plant species may be critical components of spruce-fir habitats even in their sub-dominant role. For example, many spruce-fir dependent wildlife species are cavity nesters. Yellow birch, beech, sugar maple, buckeye, and other northern hardwood tree species often provide more natural cavities and decaying wood than spruce or fir, which is critical for species such as Carolina northern flying squirrels, yellow-bellied sapsuckers, black-capped chickadees, and northern saw-whet owls (NCWRC 2005).

Range-wide Trends

Hunter et al. (1999) suggests that the available acreage of northern hardwood habitat is greater now than in the past, primarily due to expansion of northern hardwoods into areas formerly occupied by spruce-fir forests. In fact, there are places which may have been spruce or fir forests where previous disturbances (e.g. wildfire, grazing) resulted in northern hardwood stands. It remains to be seen whether these places, under natural regimes, will ultimately become mixed northern hardwood/spruce stands or whether spruce will eventually become dominant. It should be noted that significant development has occurred (and continues to occur) in northern hardwood habitats on private lands in North Carolina.

Succession of northern hardwood stands results in closed canopy conditions and decreasing habitat for bird species that rely on diverse understory development, such as Canada warbler. This lack of disturbance has reduced available habitat for other disturbance-dependent species such as golden-winged warbler and yellow-bellied sapsucker (Hunter et al. 2001). Small mammals such as masked and smoky shrews (*Sorex cinereus* and *fumeus*, respectively) can respond favorably to forest disturbance in northern hardwoods (Ford et al. 2002). However, this association with disturbance may not be true for other animals. Many former fir forests and logged or grazed areas are regenerating into northern hardwood stands without a conifer component (spruce or fir), and this may be affecting high elevation wildlife communities in general (NCWRC 2005).

Additionally, non-native pathogens are a potential problem for several tree species in this ecosystem including hemlock woolly adelgid, balsam woolly adelgid, gypsy moth, and beech scale. And furthermore, the isolated nature of several populations of wildlife, such as northern flying squirrel, northern saw-whet owl, black-capped chickadee and Weller's salamander, is likely detrimental to the genetic flow and overall long-range health of the species (NCWRC 2005).

While there is considerable overlap between habitat use by birds in spruce-fir and northern hardwood habitats, several species may increase their use of northern hardwood forests as the hardwood component increases. For example, northern hardwoods provide optimal habitat for veery (*Catharus fuscescens*), which appears to have greatly declined rangewide (Hunter et al.

1999). In addition, late successional stages of northern hardwood forests provide important habitat for black-throated blue warbler (*Setophaga caerulescens*), rose-breasted grosbeak (*Pheucticus ludovicianus*), blue-headed vireo (*Vireo solitarius*), dark-eyed juncos (*Junco hyemalis*), and black-billed cuckoos (*Coccyzus erythropthalmus*) (Hunter et al. 1999).

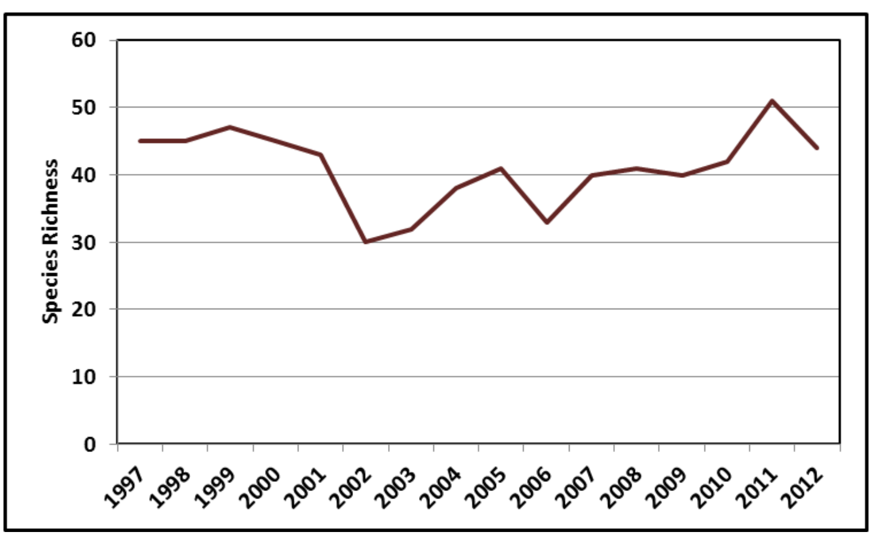
Largely because of recent declines (SAMAB 1996, Nicholson 1998), perhaps the two most ecologically important species associated with high-elevation hardwood forests are yellow-bellied sapsucker and ruffed grouse. Both of these species prefer a mixture of mature hardwood forests with large patches of early successional to sapling stage stands produced by frequent large scale disturbances.

The Appalachian yellow-bellied sapsucker is perhaps the rarest and most vulnerable of extant endemic subspecies within this physiographic area. Habitat for this species within the Southern Blue Ridge is described by Stupka (1963) as *in excess of 3500 ft., their nesting . . . in deciduous groves of mature trees where openings have been brought about by such destructive forces as lumbering, fire, windthrow, chestnut blight, etc.* Furthermore, Hamel (1992) describes sapsucker habitat as *high-elevation forests that are open with dead trees, such as near burns, diseased areas, woodland borders, and blowdowns.* Additionally, the present rarity of Appalachian yellow-bellied sapsuckers in the Great Smoky Mountains National Park appears closely related to the almost complete loss of fairly large openings since the 1930's and 1940's (Nicholson 1998). A similar situation exists for yellow-bellied sapsucker populations in the Allegheny Mountains, though at lower elevations, with extirpation nearly complete (Buckelew and Hall 1994).

Forest-Level Trends

Seventy-nine bird species have been documented from northern hardwood forests in the Nantahala and Pisgah National Forest between 1997 and 2012 (USFS 2013). Within this same monitoring period, species richness within northern hardwood forests remained stable, although annual variability is evident (Figure 19).

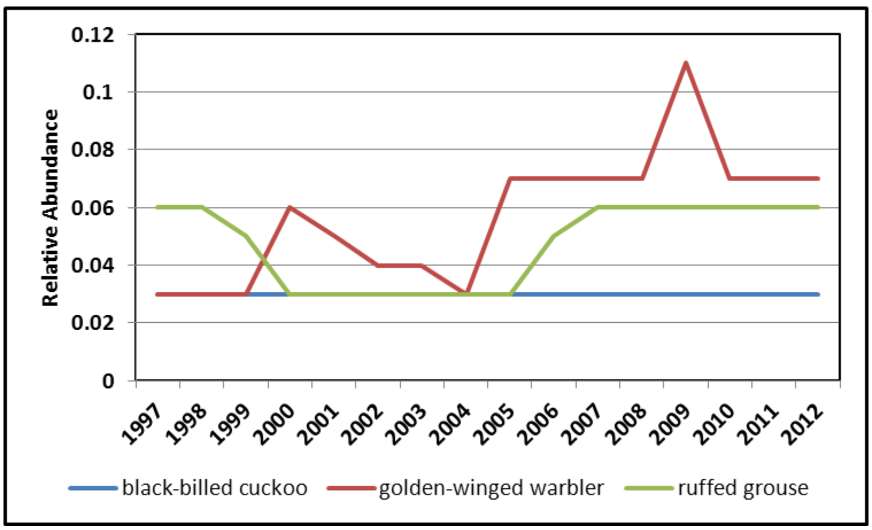
Figure 19. Landbird species richness within northern hardwood forests on the Nantahala and Pisgah NFs, 1997-2012 (USFS 2013).



Long-term monitoring data (USFS 2013) includes three priority bird species identified in the 2005 North Carolina Wildlife Action Plan (NCWAP) (NCWRC 2005) associated with northern hardwood forests that occur at low densities. These species include the black-billed cuckoo, golden-winged warbler, and ruffed grouse. Largely because they occur at naturally-low densities (i.e. are "rare"), these three species have been identified as potential Species of Conservation Concern during this plan revision process. Black-billed cuckoos are extremely uncommon on the Nantahala and Pisgah National Forests.

Populations of golden-winged warbler are increasing slightly within northern hardwood habitats (Figure 20), while decreasing sharply across the Nantahala and Pisgah NFs within the sixteen-year monitoring period. Black-billed cuckoo and ruffed grouse populations have been stable, although extremely low, within northern hardwood forests over the sixteen-year monitoring period (Figure 20).

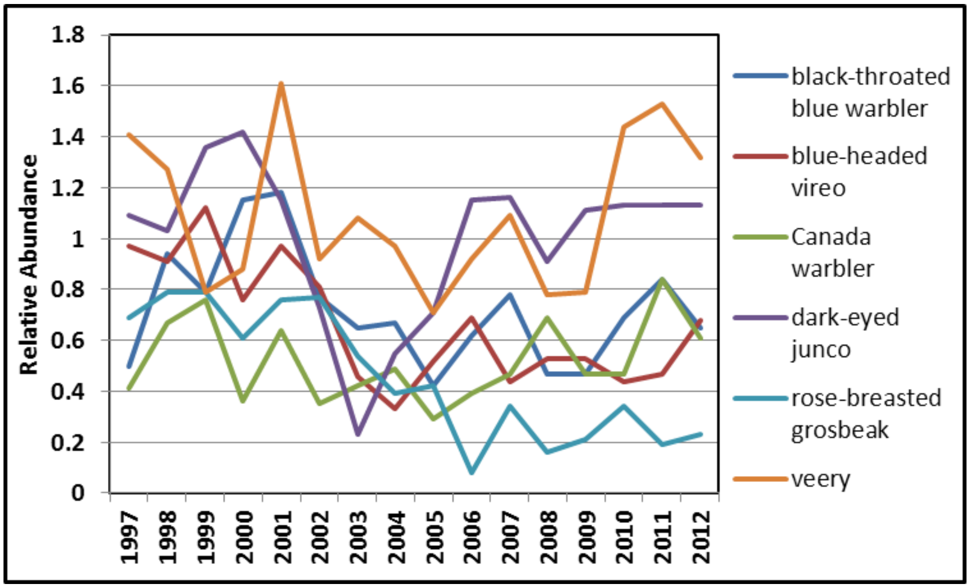
Figure 20. Relative abundance of bird species that occur at naturally-low densities associated with northern hardwood forests, 1997 through 2012 (USFS 2013).



Additionally, long-term monitoring data (USFS 2013) includes three NCWAP priority bird species associated with northern hardwood forests that occur at higher densities. These species include the Canada warbler, dark-eyed junco, and rose-breasted grosbeak. Additionally, Partners in Flight (Hunter et al. 1999) identifies black-throated blue warbler, blue-headed vireo, and veery as priority species occupying northern hardwood habitats.

Populations of these bird species have declined slightly within northern hardwood forests during the sixteen-year monitoring period, with annual variability being high. An exception to this is the veery, which is stable to increasing within northern hardwood habitats (Figure 21).

Figure 21. Relative abundance of bird species that occur at higher densities associated with northern hardwood forests, 1997 through 2012 (USFS 2013).



Generally-speaking, bird populations within northern hardwood forests are stable to slightly decreasing. Wildlife habitat quality (and therefore wildlife populations) within this ecozone is susceptible to stresses such as the population growth (i.e. urban development), acid deposition, ice damage and windthrow, and climate change. These factors, along with less vegetation management and infrequent fire disturbance, affect structural composition, and therefore habitat diversity, which is reflected in bird population trends.

Additionally, northern hardwood provide essential habitat for several animal species found nowhere else in North Carolina, including the federally-endangered Carolina northern flying squirrel (*Glaucomys sabrinus coloratus*) and a suite of terrestrial salamanders (Table 18).

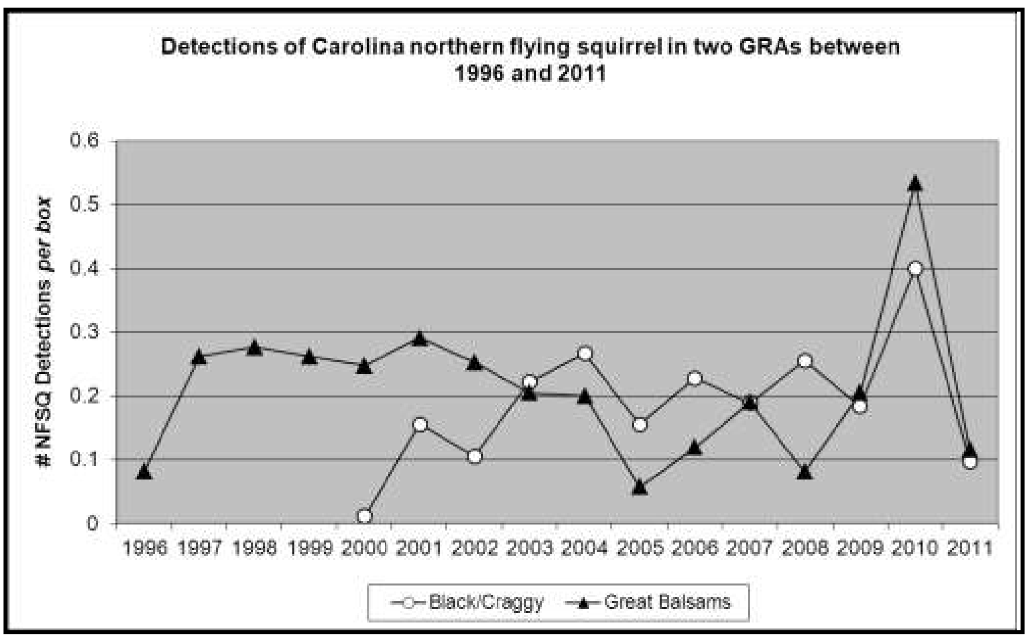
Table 18. Amphibian species identified as priority species in the NCWAP associated with northern hardwood forests.

Scientific Name	Common Name
Ambystoma maculatum	spotted salamander
Desmognathus wright	pigmy salamander
Plethodon aureoles	Tellico salamander
Plethodon Chattahoochee	Chattahoochee slimy salamander
Plethodon glutinosus sensustricto	northern slimy salamander

Plethodon longicris	crevice salamander
Plethodon richmondi	southern ravine salamander
Plethodon welleri	Weller's salamander

Although acoustic monitoring began recently (to fill in species distribution gaps), CNFS populations are monitored largely through nest box detections. Two areas in particular are monitored intensively because of the extensive nest box networks they support: the Black and Craggy Mountains and the Great Balsam Mountains. In the Great Balsam Mountains, nest box detections have remained relatively stable since 1996, although annual variability has increased since 2004. Within the Black and Craggy Mountains, nest box detections have increased slightly since 2000 (Figure 22).

Figure 22. Number of CNFS detections per nest box within the Black and Craggy Mountains and the Great Balsam Mountains, 1996 through 2011 (NCWRC 2012).



Effects of habitat change on plethodontid salamanders are well documented (Petranka 1988); such effects are less-documented on other amphibians. While no long-term monitoring data exists for most amphibians, NCWRC inventories have recently expanded the known range of many amphibian species.

Oak Ecological Zone

Oak-dominated ecosystems represent the greatest forest component across the planning area, covering about 37% of the Nantahala and Pisgah NFs and 40% of the non-Forest Service lands in the 18-county area. Oak forests have been more affected by the loss of American chestnut during the last century than other ecological zones in the southern Appalachians. In order to describe and characterize this diversity they are delineated here in four ecological zones, one separated by elevation, the remaining three separated along a moisture continuum.

Environmental Setting:

High Elevation Red Oak
This ecological zone occurs on most of the major mountain ranges, generally at elevations from 3,500-5,500 feet, across broad primary ridges and steeper secondary and tertiary ridges (Schafale and Weakley 1990; Natureserve 2013). Delapp (1978) recorded this zone across most aspects but more commonly on southeast and south exposures. In general, the type occurs on exposed landforms although the higher elevations and helps to moderate extreme temperature fluctuations. Low temperatures, high winds, ice storms, and occasional wildfires are all important natural disturbance events influencing this ecozone.

Mesic Oak Ecological Zone
This ecozone occurs from the low to mid elevations, 2,000-4,500 feet, on generally deep soils at all exposures, although it is more abundant on eastern aspects and topographic positions from 2,500 to 4,000 feet in elevation. In general, this ecozone occurs on somewhat protected to partially sheltered landforms that are convex in shape (Simon 2011). In the absence of fire, gap-phase regeneration is the greatest influence on canopy in this ecozone.

Dry-Mesic Oak Ecological Zone
This ecozone occurs across low to mid-elevations, from 2,000-4,000 feet, ridges, concave upper slopes, and occasionally in narrow dry coves (Simon 2011). In general, the ecozone can occur in locations similar to where mesic oak occurs, however, the soils tend to be more acidic and less fertile. In the absence of fire, gap-phase regeneration is the greatest influence on canopy in this ecozone.

Dry Oak Ecological Zone
This zone occurs on plateaus, ridges, and steep slopes from low to mid elevations (1,000-4,000 feet) (Natureserve 2013). It occurs on rocky, acidic, infertile upland soils with low levels of calcium, magnesium, and total base saturation, along with moderately high iron and aluminum (Fleming and Patterson 2009). In general, the type occurs on partially exposed landforms that are convex in shape (Simon 2011). Available soil moisture is most limiting out of all the oak types. Winds, ice storms, and fires are all important natural disturbance events influencing this ecozone.

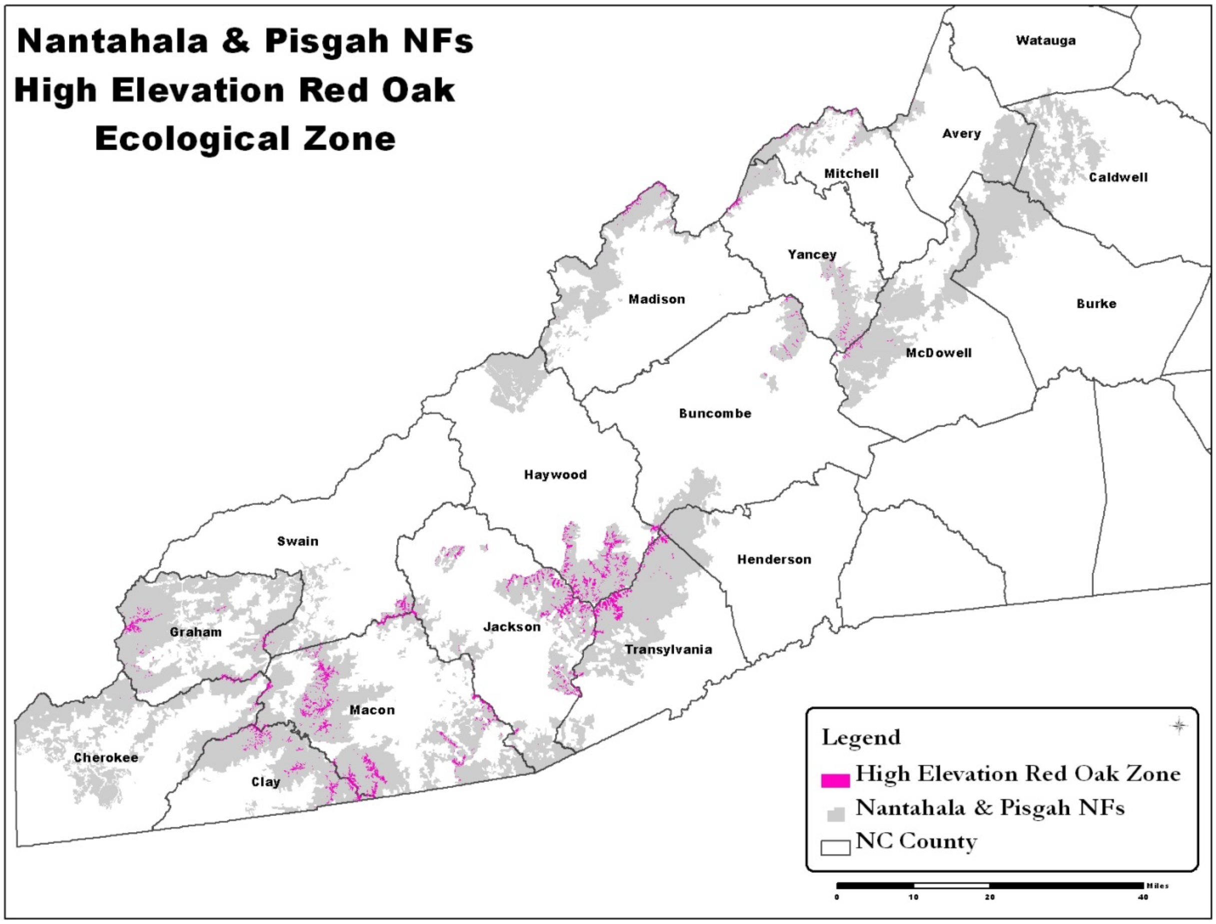
Geographic Distribution:

High Elevation Red Oak
The high elevation red oak ecozone covers approximately 3.5% (36,600 acres), of the Nantahala and Pisgah NFs. It is most common in the Balsam and Nantahala Mountain ranges but occurs dispersed across both National Forests. On lands in the surrounding 18-county area, the type is less than half as abundant, covering about 1.3%.

Five subtypes have been delineated in this type within the 18-county area. They are typic herb, rich herb, heath, orchard, and stunted woodland. Subtypes of this ecozone occur across the southern Appalachians from southern Virginia to northern Georgia and possibly northern South Carolina (Natureserve 2013). The rich herb subtype is the rarest of the five, presently only known in North Carolina in three mountain ranges with an amphibolite substrate. It is globally ranked as G2 as are the orchard forest and the stunted woodland subtypes. Both the typic herb and the heath subtypes are relatively abundant and globally ranked as G4.

The typic herb and heath subtypes for this zone are the most commonly encountered types across the Nantahala and Pisgah NFs as well as for those other lands within the surrounding 18-county area. The orchard forest subtype is less common and the stunted woodland and rich subtypes are very uncommon across both the Nantahala and Pisgah NFs and the surrounding lands.

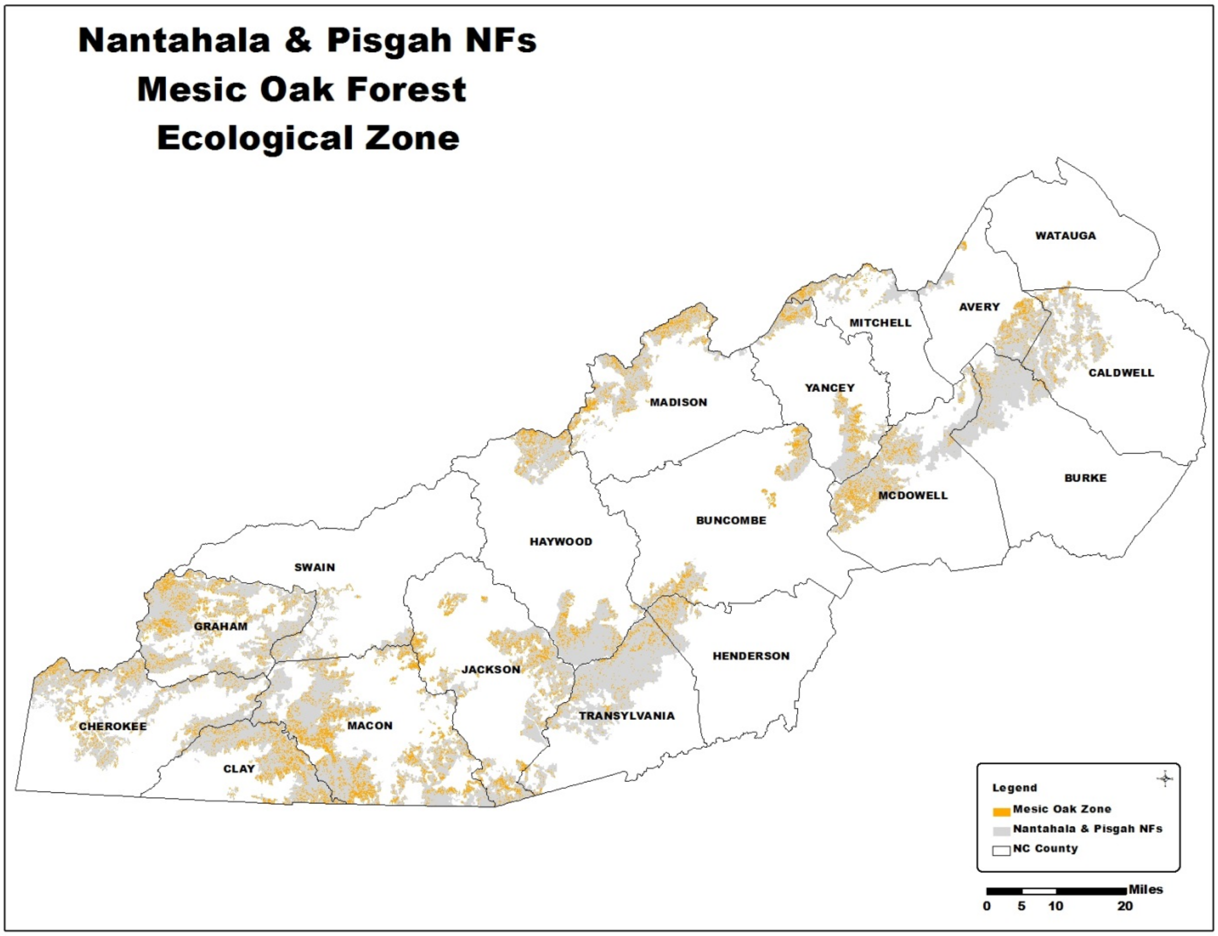
Figure 23. Distribution of High Elevation Red Oak Ecological Zone across the Nantahala and Pisgah NFs.



Mesic Oak Ecological Zone

This ecozone has a wide distribution over the Southern Blue Ridge, the Blue Ridge/Piedmont transition, the higher ridges of the Cumberland Mountains, and Ridge and Valley in southwest Virginia (Natureserve 2013). It covers approximately 18% (186,000+ acres) of the Nantahala and Pisgah NFs. Within non-national forest lands in the surrounding 18-county area, the ecozone is slightly more abundant covering about 23.5%, making it the most abundant zone on non-national forest lands. The acidic subtype of this zone is much more common across the Nantahala and Pisgah NFs as well as for those other lands within the surrounding 18-county area. The acidic subtype for this zone is considered globally secure (ranked G4G5), while the basic subtype is considered more vulnerable, ranked globally as G3 (Natureserve 2013).

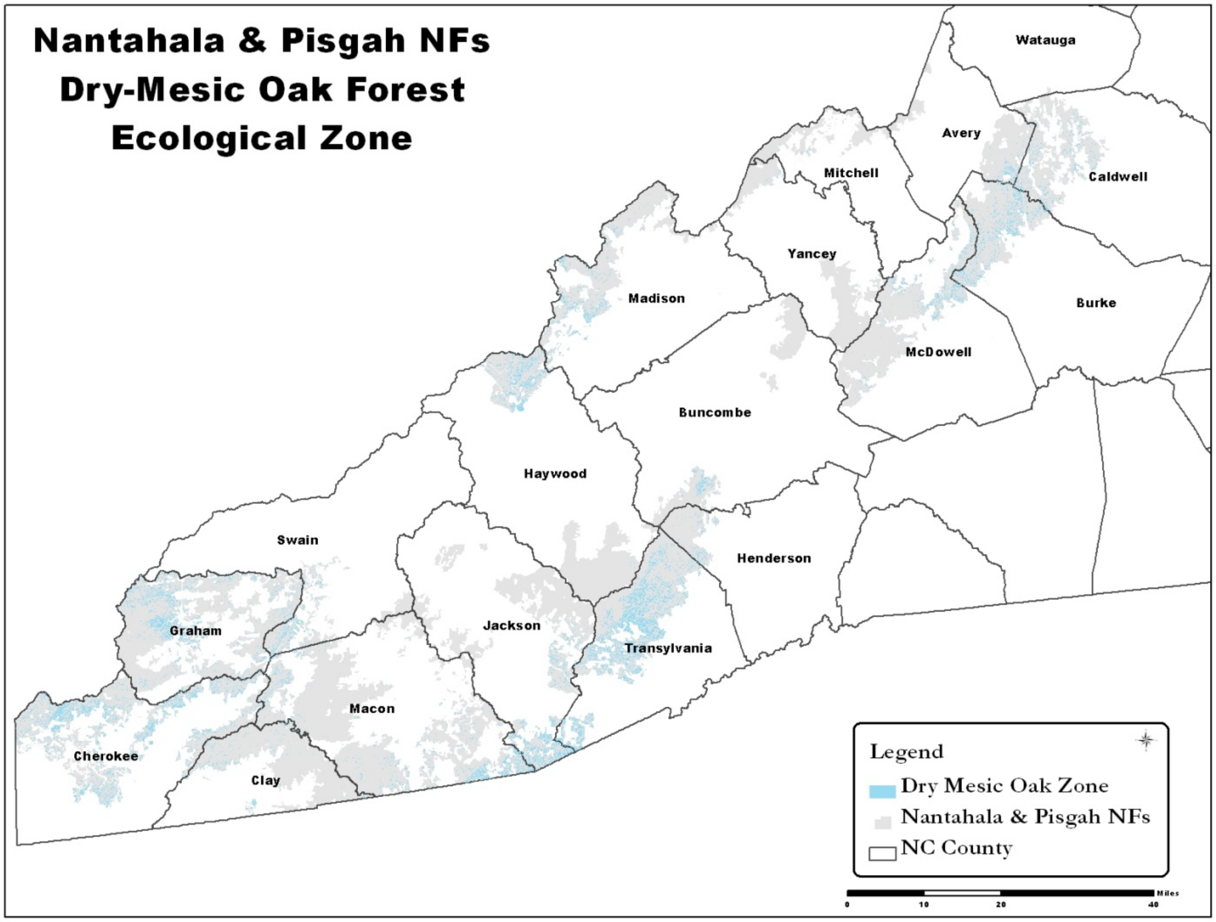
Figure 24. Distribution of mesic oak ecological zone across the Nantahala and Pisgah National Forests.



Dry-Mesic Oak Ecological Zone

The ecozone covers approximately 105,300 acres, roughly 10% of the Nantahala and Pisgah NFs. On non-national forest lands in the surrounding 18-county area, it convers close to 470,000 acres. Three subtypes have been distinguished within this ecozone: Low montane red oak, low dry, and white pine. This ecozone is widely distributed over the Southern Blue Ridge, the Blue Ridge/Piedmont transition, and the higher ridges of the Cumberland Mountains and Ridge and Valley in southwest Virginia (Natureserve 2013). The ecozone is more common in the Blue Ridge Escarpment and low elevation forests in Cherokee, Graham, Haywood, and Madison Counties. The white pine subtype for this zone is much more common across the Nantahala and Pisgah NFs as well as for those other lands within the surrounding 18-county area. The white pine subtype for this zone is ranked G3G4, while the low dry is considered more vulnerable, ranked globally as G2G3 (Natureserve 2013). In comparison, the low montane red oak forest is globally ranked as G4, apparently being more common outside of North Carolina.

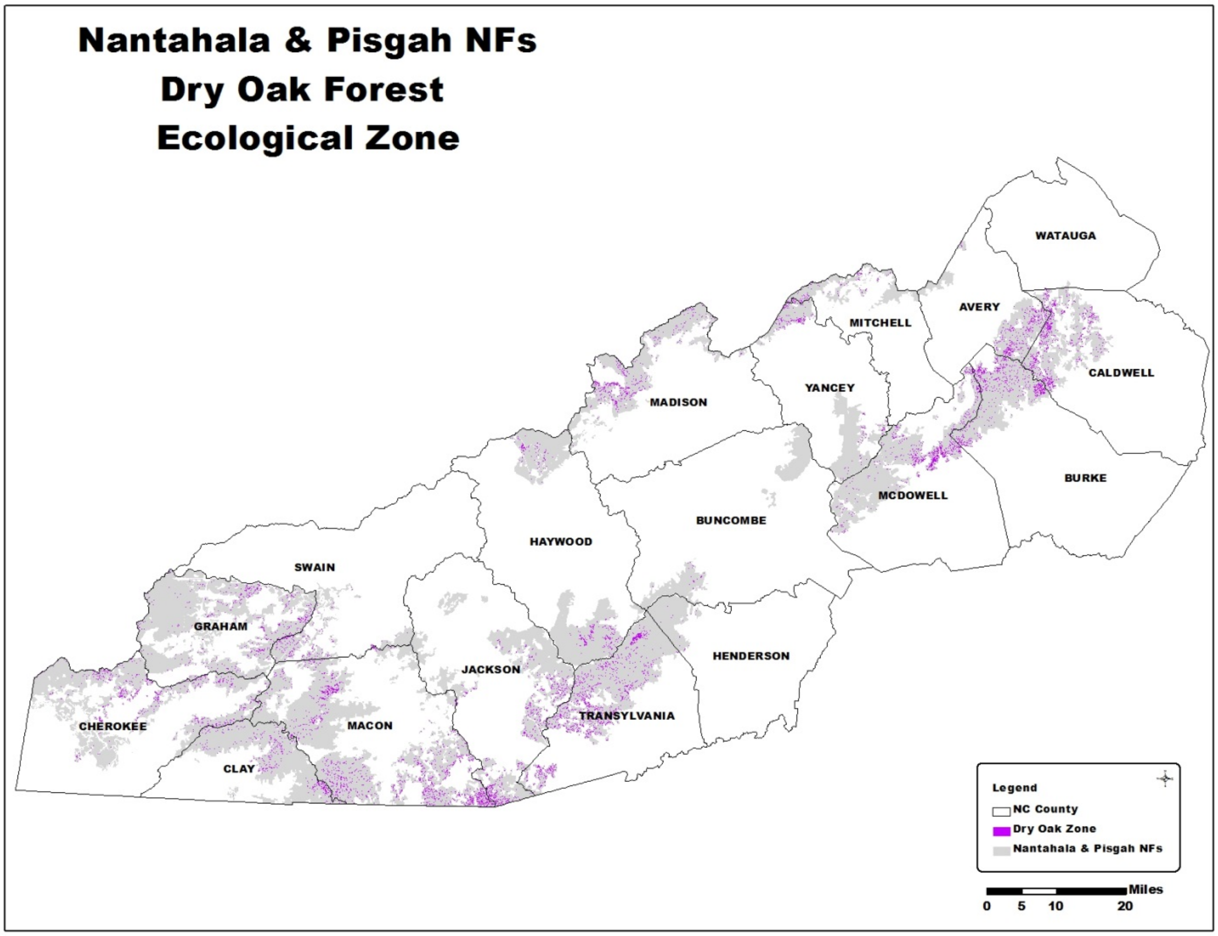
Figure 185. Distribution of Dry-Mesic Oak Ecological Zone across the Nantahala and Pisgah National Forests.



Dry Oak Ecological Zone

Across the Nantahala and Pisgah NFs, this ecozone covers about 60,000 acres, (approximately 6% of the Forest). It is relatively evenly distributed across both forests, with greater abundance within the Grandfather Ranger District and along the Blue Ridge Escarpment in Jackson and Macon Counties. Approximately 260,000 acres occur on non-national forest lands in the surrounding 18-county area. Three subtypes have been identified within this ecozone, dry heath, herb, and white pine. In total distribution, this ecozone has a broad range, from West Virginia and Kentucky, south to Georgia and South Carolina, distributed over the Southern Blue Ridge, the Blue Ridge/Piedmont transition, the Cumberland Mountains, and the Ridge and Valley (Natureserve 2013). The dry heath subtype for this ecozone is most common. This subtype is considered globally secure with a rank of G5. The herb subtype is less common in the planning area than the dry heath, but is abundant across its range, globally ranked as G4G5. The white pine subtype is the least common of the three and is ranked globally as G3 (Natureserve 2013).

Figure 26. Distribution of the dry oak ecological zone across the Nantahala and Pisgah NFs.

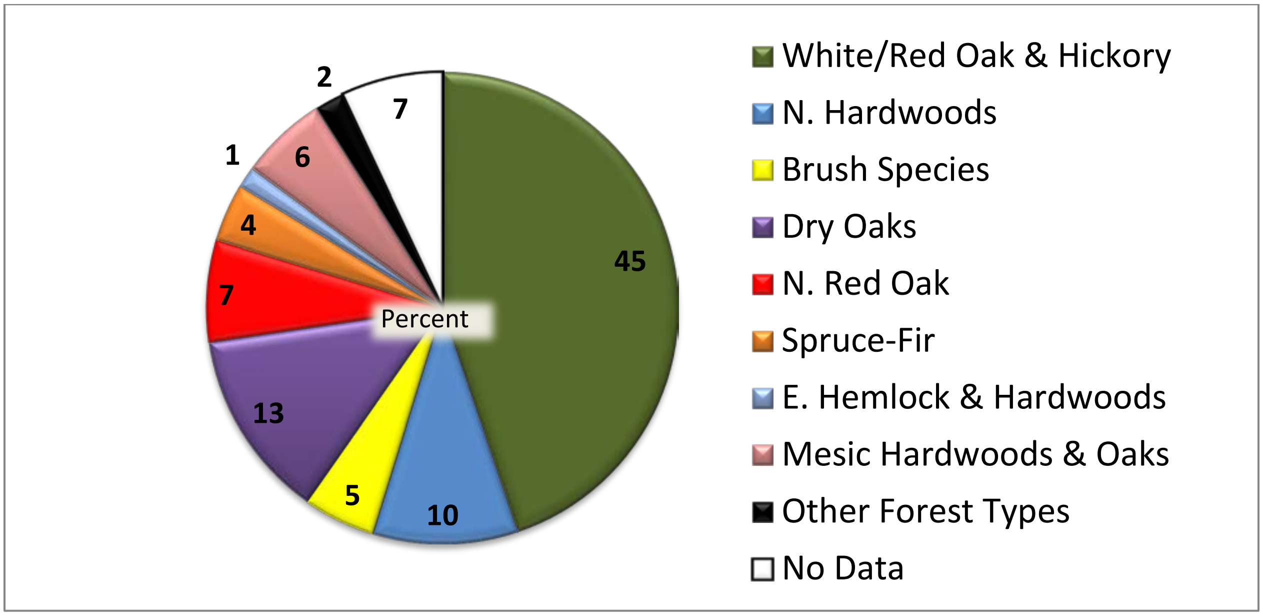


FSVeg Types

High Elevation Red Oak

Within Nantahala and Pisgah NFs, the FSVeg database identifies 2,589 acres as having components of the high elevation northern red oak community. These acres represent approximately 7% of the ecozone (Figure 27) and may represent an underestimation of the high elevation red oak ecozone. Other large portions of the ecozone may be close in composition to the BpS description such as the white/red oak hickory types (45%). Commonly adjacent communities like spruce-fir and northern hardwoods make up another 14% of the high elevation northern red oak community (Figure 27) (Landfire 2009).

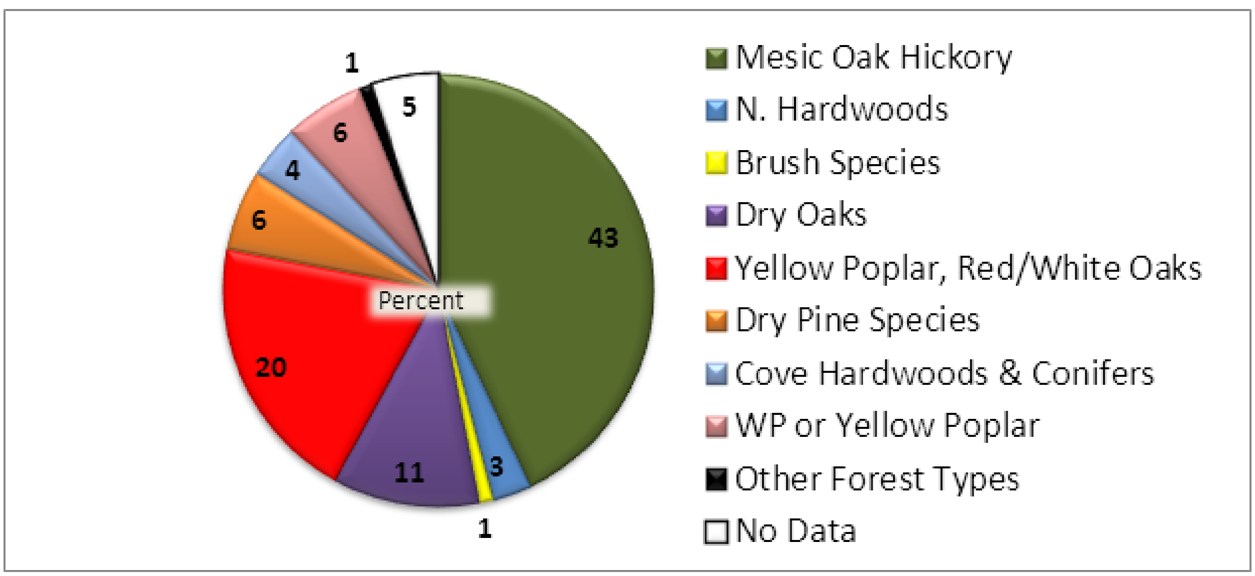
Figure 27. Nantahala & Pisgah NFs FSVeg forest type breakdown within the high elevation northern red oak ecozone.



<u>Mesic Oak Ecological Zone</u>

Within Nantahala and Pisgah NFs, the vegetation management database identifies 80,995 acres as having components of the mesic oak community. These acres represent approximately 43% of the modeled ecozone (Figure 28). Other communities of close association make up another 31% on more mesic or drier portions of the landscape (Figure 28) (Landfire 2009). Roughly 6% of the ecozone contains forest types that may represent a disturbed condition.

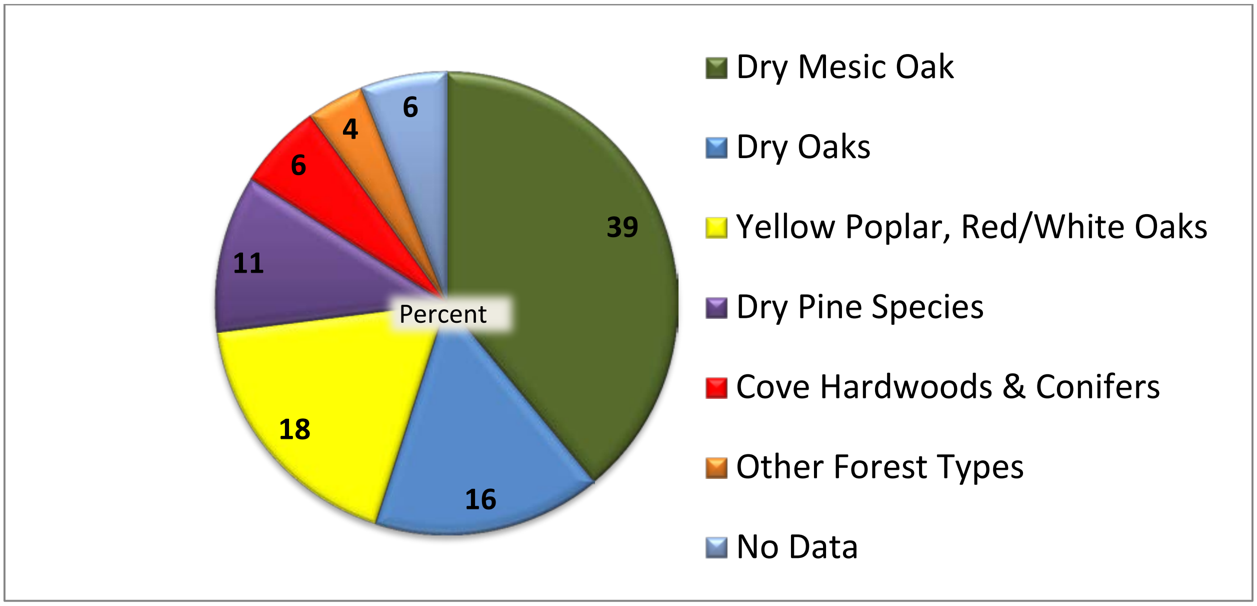
Figure 28. Nantahala and Pisgah NFs FSVeg forest type breakdown within the mesic oak ecozone.



Dry-Mesic Oak Ecological Zone

Within Nantahala and Pisgah NFs, the vegetation management database identifies 38,450 acres as having components of the dry-mesic oak community. These acres represent approximately 39% of the ecozone (Figure 29). Communities of close association make up the majority of the rest of the ecozone (Figure 29) (Landfire 2009). Roughly 9% of the ecozone contains forest types that may represent a disturbed condition.

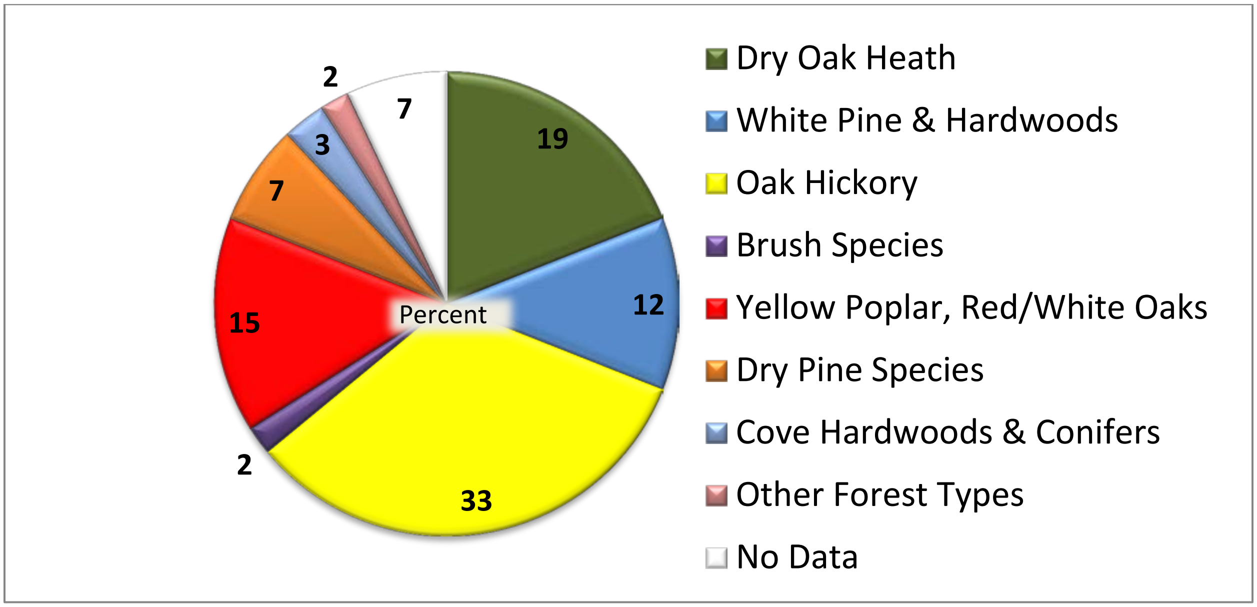
Figure 29. Nantahala and Pisgah NFs FSVeg forest type breakdown within the dry-mesic oak ecozone.



Dry Oak Ecological Zone

Within Nantahala and Pisgah NFs, the vegetation management database identifies 10,589 acres as having components of the dry oak community. These acres represent approximately 19% of the ecozone (Figure 30). Other communities typically in close proximity to the dry oak heath ecozone make up another 72% of the area (Figure 30) (Landfire 2009).

Figure 30. Nantahala and Pisgah FSVeg forest type breakdown within the dry oak heath ecozone.



Composition

High Elevation Red Oak

Five main plant community associations have been delineated within the high elevation red oak ecozone, primarily differing by structure or vegetation (Schafale 2012; Natureserve 2013). This ecozone is dominated by more than 50% red oak (*Quercus rubra*), often up to 75%, with lesser amounts of white oak (*Quercus alba*), chestnut oak (*Quercus montana*), red maple (*Acer rubrum*), striped maple (*Acer pensylvanicum*), and yellow birch (*Betula allegheniensis*). For the rich herb subtype, tree species such as white ash (*Fraxinus americana*) and sugar maple (*Acer saccharum*) are also common. Chestnut (*Castanea dentata*) saplings and other small trees often persist in the subcanopy or shrub layer. Three of the subtypes have dense shrub layers, consisting of Catawba Rhododendron (*Rhododendron catawbiense*), great laurel (*Rhododendron maximum*), flame azalaea (*Rhododendron calendulaceum*), highbush blueberry (*Vaccinium simulatum*), highbush cranberry (*Vaccinium erythrocarpum*), or mountain laurel (*Kalmia latifolia*). Herb diversity is greatest within the remaining two subtypes and typically contains Pennsylvania sedge (*Carex pensylvanica*), white snakeroot (*Ageratina altissima var. roanensis),* wood-nettle (*Laportea canadensis*), hay-scented fern (*Dennstaedtia punctilobula*), and New York fern (*Thelypteris noveboracensis*). In rich herb subtypes, black cohosh (*Actaea racemosa*), stoneroot (*Collinsonia canadensis*), and bloodroot (*Sanguinaria canadensis*) are common. Species richness varies greatly across the subtypes within this zone, from a low of 14 species in the shrub dominated ones, to greater than 85 species in the rich herb type (Ulrey 1999; Carolina Vegetation Survey 2013).

Mesic Oak Ecological Zone

Two main plant community associations are included within this zone, an acidic subtype and a basic subtype (Schafale 2012; Natureserve 2103). This ecozone is dominated by white oak (*Quercus alba*), red oak (*Quercus rubra*), and chestnut oak (*Quercus montana*), with varying amount of red maple (*Acer rubrum*), pignut hickory (*Carya glabra*), red hickory (*Carya ovalis*), mockernut hickory (*Carya tomemtosa*), or tulip poplar (*Liriodendron tulipifera*).

Shrub density varies across the two subtypes. Within the acidic subtype, shrub density can be moderate to dense, typically with many deciduous species such as bear huckleberry (*Gaylussacia ursina*), buffalo-nut (*Pyrularia pubera*) and mountain holly (*Ilex montana*). Herb species can be sparse in the acidic subtype with common herbaceous species including wood betony (*Pedicularis canadensis)*, featherbells (S*tenanthium gramineum*, New York fern (*Thelypteris noveboracensis*), squawroot (*Conopholis americana*), whorled loosestrife (*Lysimachia quadrifolia*), *Coreopsis major*, and cow-wheat (*Melampyrum lineare*). This compares to the basic subtype, which has much higher herb diversity, more reminiscent of rich cove forest including species such as black cohosh, bloodroot, and maiden-hair fern. Shrubs are generally sparse within this subtype. Herbaceous diversity is highly variable within the two subtypes, ranging from 29 to 115 species (Natureserve 2013).

Dry-Mesic Oak Ecological Zone

This ecozone is dominated by white oak (*Quercus alba*), mockernut hickory (*Carya tomemtosa*), red oak (*Quercus rubra*), southern red oak (*Quercus falcata*), scarlet oak (Quercus coccinea), and black oak (Quercus velutina), with varying amounts of red maple (*Acer rubrum*). Red oak dominates in the low montane subtype, white pine in its subtype, and scarlet oak and southern red oak in the low dry subtype. A heath shrub layer is often present, in particular bear huckleberry (*Gaylussacia ursina*), sweet-shrub (*Calycanthus floridus*), mountain laurel, or white laurel for either the montane red oak or the white pine subtype. Low bush blueberry (*Vaccinium pallidum*) and flame azalea (*Rhododendron calendulaceum*) are often present in the low dry subtype. More than half of the forests in this ecozone have a shrub density higher than 53% cover.

Herb diversity is highly variable across the three subtypes and dependent on the shrub density. Typically, diversity is low to moderate, but can be relatively high. Vascular plant counts within the community vary from a low of 33, to a high of 103 (Ulrey 1999). Fern diversity can be high within the ecozone. On the low dry subtype, grasses such as little bluestem, Indian grass (*Sorghastrum nutans*), and needle grass (*Piptochaetium avenaceum*) can be abundant if maintained with frequent fire.

Dry Oak Ecological Zone

This ecozone is dominated by chestnut oak and scarlet oak with varying amounts of black oak, white oak, red maple, mockernut hickory, pignut hickory, blackgum, Virginia pine (*Pinus virginiana*), and shortleaf pine (Schafale and Weakley 1990; Simon 2011). White pine is common in the white pine subtype and may be tied to the long absence of fire (Landfire 2009; Natureserve 2013). Ericaceous shrubs dominate white pine subtype, including bear huckleberry (*Gaylussacia ursina*), black huckleberry (*G. baccata*), hillside blueberry (*Vaccinium pallidum*) and mountain laurel (*Kalmia latifolia*). Herbaceous diversity is relatively sparse across the dry heath and white pine subtypes with cow-wheat (*Melampyrum lineare*), various Dichanthelium species, yellow stargrass (*Hypoxis hisutus*), trailing arbutus (*Epigaea repens*), spotted wintergreen (*Chimaphilia maculata*), Carolina lily (*Lilium michauxii*), wild indigo (*Baptisia tinctoria*) and bellwort (*Uvularia puberula*) most prevalent. Within the herb subtype, shrub density is typically less than 20% cover and consists of short shrubs such as low-bush blueberry or maple-leaf Viburnum (*Viburnum acerifolium*). Herb diversity within this subtype is moderate and more similar to dry-mesic oak types. Species richness varies across the zone from a low of 28 to over 65 species (Ulrey 1999).

Connectedness

High Elevation Red Oak

At the highest elevations, above 5,500 feet, spruce-fir forest can be upslope. While red oak forest is often upslope of the drier subtype of northern hardwood forest it can intergrade to mesic oak or dry oak forest between 4,000-4,500 feet elevation. Heath balds can occur on adjacent drier steep thin-soil slopes. Open rock outcrops, such as high elevation granitic domes, are often surrounded by high elevation red oak forest. Portions of this zone have been converted to grassy balds with a mix of native and European grasses across both the Nantahala and Pisgah NFs. Patch sizes in this ecozone typically exceed 30 acres and can exceed 250 acres across some of the flat primary and secondary ridges in the Balsam and Nantahala Mountains.

This habitat is not limited across the Nantahala and Pisgah NFs, however fire-maintained habitat is very patchy. Some of the subtypes are being replaced in the understory with mesic tree species such as sugar maple and yellow birch. As a result, fire adapted plant species that occur in openings across this type can be widely dispersed or only occur in very small populations.

Mesic Oak Ecological Zone

Adjacent forests connected to this zone are variable. At its upper range it can grade to high elevation red oak forest. It is typically upslope of rich cove or acidic cove forest on convex slopes. It can grade to mesic-oak forest on moderate slopes and dry oak forest on steep slopes. Montane acidic and calcareous cliffs can occur embedded within this ecological zone.

Patch sizes of this habitat are variable from under 25 acres to more than 200 acres, across some of the upper concave and convex slopes in the Balsam and Nantahala Mountains. This habitat is not limited across the Nantahala and Pisgah NFs; however fire-maintained habitat is very limited. Some of the subtypes are being replaced in the understory with more mesic tree species such as red maple and blackgum, and oaks are not effectively regenerating. As a result fire adapted plant species that occur in more openings across this type can be widely dispersed or only occur in very small population sizes.

Dry-Mesic Oak Ecological Zone

This ecozone can occur upslope of either rich cove or acidic cove forest or mesic oak-hickory forest. On drier slopes, it can grade to dry oak forest or pine-oak forests, and can grade to high elevation red oak forest at upper elevations. Larger outcrops, such as low elevation or high elevation granitic domes, are often surrounded by dry-mesic oak forests. Patch sizes of this habitat are variable, from a few acres on steep narrow ridges to more than 50 acres on dry west or south-facing slopes. This ecozone is not limited across the Nantahala and Pisgah NFs;

however fire-maintained habitat is patchy. As a result, fire-loving species that occur within this type can be widely dispersed or only occur in very small population sizes.

Dry Oak Ecological Zone
This ecozone typically occurs upslope of dry-mesic oak forest and occasionally mesic oak forest and can grade to high elevation red oak forest in upper elevations. Rocky outcrop communities, including low and high elevation granitic domes, rocky summits, and glades are often found adjacent to this zone. Carolina hemlock bluffs may be found embedded within the zone. Patch sizes are variable, from a few acres on steep narrow ridges to more than 50 acres on dry west or south-facing slopes. This ecozone is not limited across the Nantahala and Pisgah NFs; however, high quality fire-maintained habitat is patchy.

The effect of fire suppression is uncertain this zone as well as the pine-oak/heath zone. In the absence of fire, pines may drop out of pine-oak/heath forests. As such, the forest resembles dry oak forest. Fire-loving species that occur within this type can be widely dispersed or only occur in very small populations.

Designated Areas

High Elevation Red Oak
A little more than 42% of this high elevation ecozone is currently within existing designated areas. Those acres within the designated areas are present across the two forests (although sparse) within the northern Nantahala Mountains and the Cowee Mountains.

Mesic Oak Ecological Zone
A little more than 24% of the mesic oak ecological zone is within existing designated areas. Those acres within the designated areas are present across the two forests (although sparse) within the northern Nantahala Mountains and the Cowee Mountains.

Dry-Mesic Oak Ecological Zone
A little less than 16% of dry-mesic oak ecological zone is currently within existing designated areas. Those acres within designated areas are present across both forests although very sparse on the Tusquitee and Appalachian Ranger Districts.

Dry Oak Ecological Zone
A little less than 25% of the dry oak ecological zone is currently within existing designated areas. Those acres within the designated areas are present across both forests although very sparse within the Cheoah, Tusquitee and Appalachian Ranger Districts.

Disturbance Dynamics

High Elevation Red Oak
Chestnut blight has heavily influenced this zone and undoubtedly resulted in the current dominance by red oak. This ecozone is influenced by high winds. The creation of canopy gaps and large openings are driven by wind events and ice storms. Patch sizes can vary from single trees to numerous trees, several acres in size. Fire is considered an important factor in maintaining this habitat with a fire return frequency as low as 15 years (Landfire 2009). In

contrast, moderate to catastrophic fires are less frequent, at a 100 - 600 year interval, generally following a drought or a disturbance that has cause an abundance of downed woody debris.

Fire suppression following the mid-1900s has affected the structure of this community, probably resulting in a greater shrub density and an increase in more mesic northern hardwood species. Shrub densities, consisting of both deciduous and evergreen species, exceed 50% in half of the ecozone. An emphasis on larger landscape burns during the last seven years across the Nantahala and Pisgah NFs has resulted in some burns within the high elevation red oak ecozone, amounting to approximately 2,100 acres, which represents 5.7% of the zone across the two forests. Of the four dominant oak ecozones, a greater percent of this zone is being burned.

Compared to other ecozones, high elevation red oak forest is not as susceptible to non-native plant species infestations as the other oak forests, probably due to its presence at high elevations and relatively infrequently recent disturbance within the zone. Perhaps the most invasive species within this zone is oriental bittersweet.

Mesic Oak Ecological Zone

American chestnut occurred throughout this ecozone and its loss has influenced the present dominance of canopy species. In the absence of fire, gap-phase regeneration has the greatest influence on the canopy, creating small gaps while occasional ice storms or extreme wind events can result in larger canopy openings. Pre-settlement forests suggest a fire return interval with the predominance of low intensity fires every 15-25 years, and occasionally more intense fires would help to maintain and regenerate the fire tolerant oaks (Landfire 2011). Various research shows oaks need recurrent fire for long-term stability and regeneration (Lorimer 1985; Abrams 1992). Fire may have a beneficial influence on oaks by reducing competition from more fire-sensitive tree species in the sapling layer (Lorimer 1985). Fire reduces the amount of litter under a stand, which, according to Lorimer, may discourage rodent predation of acorns. Fire may indirectly influence rodent populations as well, by reducing available nest sites and food availability. Fire disturbance can play a role in selecting against thin barked mesic hardwoods.

In montane oak forests sampled in Shining Rock Wilderness, saplings of red maple and silverbell suggest dominance in the future canopy by these thin barked species with oak species diminishing (Newell and Peet 1996). Communities across the Chattooga River watershed appear to be changing from oak-dominance to more shade tolerant red maple, black birch and blackgum (Meir and Bratton 1996). Fire suppression during the last 50-70 years has perpetuated the even-aged structure and allowed for the dominance of more mesic midstory and canopy species, in particular red maple, blackgum and possibly tulip poplar within this ecozone. Given the abundance of this zone and its adjacency to other more fire-adapted types, the likelihood of this zone experiencing periodic surface fires is high. Within the oak-dominated ecozones the mesic oak zone has a more open shrub layer (53% with less than 50% shrub cover), likely a result of intense shade from well-developed overstories and midstories. Within the last seven years, slightly less than 4% of this ecozone has had a prescribed burn.

Compared to other ecozones, mesic oak forest has a high potential for non-native invasive plant species infestation. It is the most susceptible of the oak dominated types; up to 14 targeted non-native invasive plants have been located within this zone. During the last 10 years, this zone and the dry-mesic oak ecozone had the most young forest habitat created within the oak-dominated ecozones. Only rich cove forest had more management activity. As a result, this ecozone has the second largest problem with invasive plant outbreaks across the Nantahala and Pisgah NFs.

Dry-Mesic Oak Ecological Zone

American chestnut occurred throughout this ecozone and its loss has influenced the present dominance of canopy species as well as influenced the spread of aggressive mesic species such as white pine and red maple. Gap-phase regeneration is the greatest influence on the canopy, creating small gaps while occasional ice storms or extreme wind events can result in larger canopy openings. Fire suppression during the last 50-70 years has perpetuated the even-aged structure and allowed for the dominance of more mesic midstory and canopy species, in particular white pine across the Blue Ridge Escarpment. While the white pine subtype is the dominate forest in this ecological zone, it is uncertain what the natural occurrence of white pine was given the history of fire suppression since the 1940's (Schafale 2012; Natureserve 2013). Pre-settlement forests suggest a fire return interval of low intensity fires every 10-15 years, and occasional more intense fires which would help to maintain and regenerate fire tolerant oaks (Landfire 2011). As previously mentioned for the mesic oak ecozone, fire would help to regenerate oak and allow the saplings to move into the overstory gaps. More than half of the dry-mesic oak ecozone has greater than 50% shrub cover, which is likely a consequence of fire suppression. Within the last seven years, a little more than 5% of this ecozone has had a prescribed burn conducted.

Compared to other ecozones, dry-mesic oak forest is moderately susceptible to non-native plant species infestations. While not as infested as open understory mesic forests, up to eight targeted non-native invasive plants have been located within the zone. In general, the spread of infestation is not as great as within rich cove forest, but large occurrences of Chinese silvergrass have been recorded.

Dry Oak Ecological Zone

American chestnut occurred throughout this ecozone and its loss has influenced the present dominance of canopy species as well as influenced the spread of aggressive mesic species such as white pine and red maple. Gap-phase regeneration has the greatest influence on the canopy, creating small gaps while, occasional ice storms or extreme wind events can result in larger canopy openings. Fire suppression during the last 50-70 years has perpetuated the even-aged structure and allowed for the dominance of more mesic midstory and canopy species, in particular white pine across the Blue Ridge Escarpment. As with the dry-mesic white pine subtype, it is uncertain what the natural occurrence of white pine was given the long history of fire suppression in the 1900s (Schafale 2012; Natureserve 2013). Pre-settlement forests suggest a fire return interval with the predominance of low intensity fires every 7-10 years, and occasional more intense fires would help to maintain and regenerate the fire tolerant oaks (Landfire 2011). The dry oak zone would have less competition from mesic species in comparison to other oak zones and may more easily regenerate oaks in the absence of fire. More than half of the dry oak zone has greater than 50% shrub cover, which is likely a consequence from a lack of recurrent burns. Within the last seven years, a little less than 4.5% of this ecozone has had a prescribed burn.

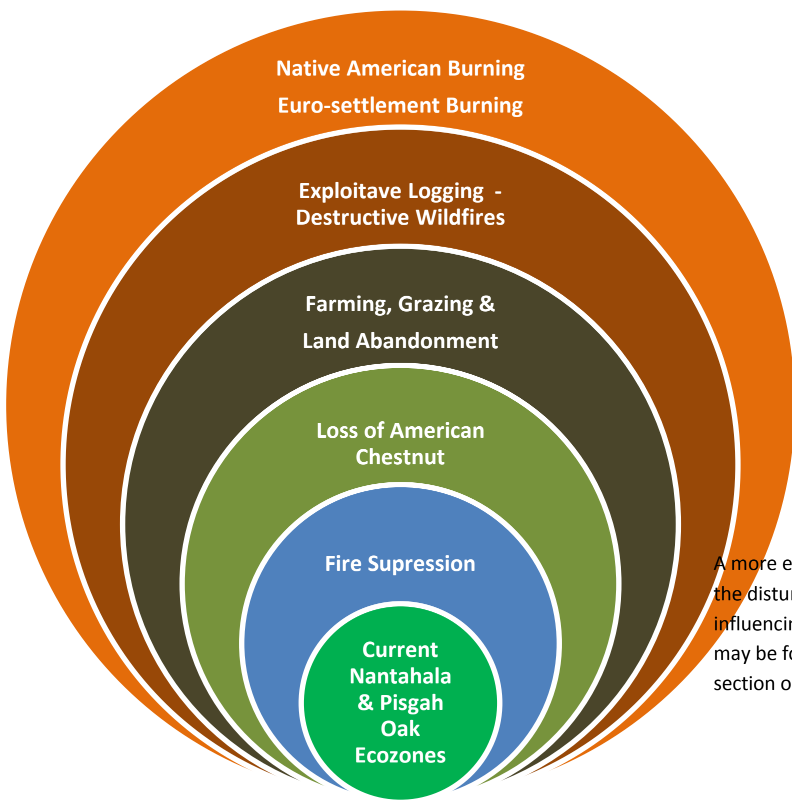
Compared to other oak ecozones, dry oak forest is the least susceptible to non-native plant species infestations. The greatest threat from invasive plants to this ecozone occurs in areas where a high-intensity, high-severity wildfire has completely consumed the duff layer and removed the overstory canopy. Within these sites, princess tree (*Paulownia tomentosa*), tree-of-heaven (*Ailanthus altissima*), butterfly bush (*Buddleja davidii*), Chinese silvergrass (*Miscanthus sinensis*), and spotted knapweed (*Centaurea biebersteinii*) have rapidly invaded (Kuppinger and White 2007). In sites with less severe wildfires within this zone, the spread of invasive non-native species has not occurred.

Oak Ecozones Vegetation Structure

The ecozones dominated by oak communities (high elevation red oak, mesic oak, dry-mesic oak, dry oak) generally follow similar structural development pathways. In the following discussion, overall structural conditions will be described together and differences unique to a particular ecozone will be detailed as needed.

The majority of the oak forests present on the Nantahala and Pisgah NFs today (similar to the rest of the oak forests in the Appalachian Mountain chain) have developed because of historical land use practices and events, including loss of the American chestnut, making the current composition and structure anthropogenically influenced (Figure 31) (Clatterbuck 1991; Abrams 2003; Nowacki and Abrams 2008; Johnson et al. 2009; Lorimer 2001; Shifley and Thompson III 2011). Much of the debate surrounding these forest communities is on the degree and scale that the historical practices or events exerted their influence. Additionally, the same land use history has limited the information currently available about the structure and composition of pre-European settlement forests (Lorimer and White 2003; Thomas-Van Gundy and Strager 2011). It is likely that the Southern Appalachian forests of today do not resemble past forests in species composition or structure (Nesbitt 1941; Oak 2002; Abrams 2003).

Figure 31. Anthropogenic influences on current oak ecozone structure and composition.



A more expanded description of the disturbances and events influencing species composition may be found in the disturbance section of the Assessment.

Currently, the overall structure of forests in the oak ecozones is generally described as mature, oak-dominated overstories, but the structure also includes the presence of many other upland tree species. Representation of other species within the main canopy varies with aspect and topographic position, local moisture gradients, site productivity and past disturbances. The midstory and understory may be open or closed depending on the overstory structure and density, site productivity and species present. More open overstories commonly result in denser mid- and understories.

Due to the land use history, many southern Appalachian oak-dominated forests are presumed to be more even-aged than their their pre-settlement conditions (Lorimer 2001). After the series of events detailed in Figure 31, oak species were able to take advantage of their relatively high abundance as advanced regeneration in the understory built by large-scale Native American and early settler burning (Clatterbuck 1991; Abrams 2003; Lorimer and White 2003; Fralish 2004; Nowacki and Abrams 2008). As the structure of these disturbed forests was developing, a primary component, American chestnut, was removed via chestnut blight (*Cryphonectria parasitica*) allowing then-abundant oak species to fill the void (Muzika et al. 1999; Oak 2002). However American chestnut may have begun disappearing from riparian areas and moist soils as early as the 1820's due to the root rot fungus *Phytophthora* that was introduced into North America (Wang et al. 2013).These age structural conditions are relatively commonplace across the eastern US (Muzika et al. 1999; Oak 2002; Lorimer and White 2003; Fralish 2004; Luppold and Miller 2005; Thomas-Van Gundy and Strager 2011). Fralish (2004) noted that the structure of central hardwood oak forests is typically even-aged with a single high relatively thin overstory, easily penetrated by sunlight. Shifley and Thompson III (2011) reported that more than half of the forest lands in the central hardwood region are between 40 and 80 years of age. The majority of the forests present in the Nantahala and Pisgah oak ecozones are in an older age range of 80 to 120 years, having been harvested earlier as land clearing progressed from east to west across the Appalachians and into the Ohio Valley (Shifley and Thompson III 2011).

Due to their relatively even-aged condition, the forest stands and communities in the oak ecozones will generally follow a known trajectory in stand structure development (Figure 32, Johnson 2004). Within the four oak-dominated ecozones, the rates that these stages (or phases) occur are largely driven by site productivity and elevation related environmental conditions (Muzika et al. 1999). The development of a stand through the stand initiation phase (per Johnson et al. 2009) occurs at a slower rate in dry oak or high elevation red oak ecozones than the dry-mesic oak or mesic oak ecozones. In eastern oak forests, the stand initiation phase (Young Forest Habitat) lasts between 10 and 20 years where gaps in the new vegetative cover persist until new trees and other vegetation becomes established. This occurs as each microsite develops conditions suitable for the species present (or new invaders) to germinate (Nyland 1996; Oliver 1981; Johnson 2004; Loftis et al. 2011). Additionally, the frequency and scale of disturbance in the dry oak and high elevation red oak ecozones may result in greater portions of their communities being in the stand initiation/young forest habitat/early-successional class condition than the other oak communities.

Stands created as a result of past management or natural disturbance events will advance in age and structural development similar to Figure 32.

The influence of disturbance on structural development increases with age and size of the overstory trees. When stands are young, the crowns of smaller trees are able to quickly occupy space created in the canopy by disturbance, limiting light that reaches the forest floor and therefore limiting understory development (Figure 32, Phases 1 and 2). During these early stages (especially phase 2) the species in the main canopy typically shift to those best adapted to the site as they obtain and hold dominant and co-dominant positions through intense inter-tree competition (Johnson 2004).

Figure 32. Stand development stages after a disturbance (natural or anthropogenic) that removes the existing mature vegetation (adapted from Johnson et al. 2009).

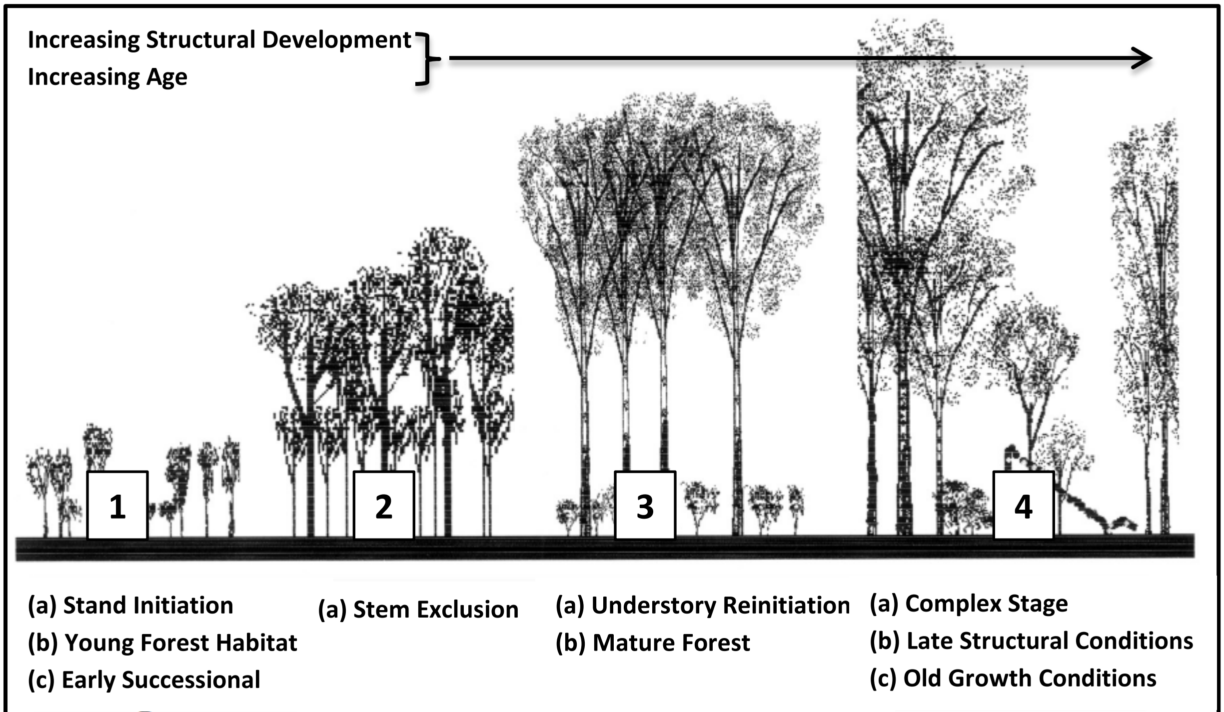


Figure 1—Stages of stand development occurring after a major disturbance that destroys all or most of the parent stand (from Johnson and others 2002).

Our modern oak forests have aged relatively free from disturbance for 70 to 90 years or have been capable of rapidly recovering from disturbance due to their younger age. Overall, oak stands are thought to be denser than in the past because of this lack of disturbance (Nesbitt 1941; Arthur et al. 2012). The understory reinitiation phase begins as mortality and disturbance agents create gaps in the main canopy that are not as quickly filled by surrounding trees. Additions of light to the ground stimulate development of an understory including advance regeneration (Johnson 2004) and development of increased vertical structure (Figure 32, phase 3). Oak decline occurring on more mesic sites that represent the extremes for oak dominance (Oak 2002; Arthur et al. 2012) yield stands with high proportion of oaks and poplar in the overstory and with maples in high proportion in the understory (Muzika et al. 1999). Pre-historic and historic fire use is considered the disturbance that supressed the development of a dense mesic midstory on all sites that are currently experiencing oak regeneration development problems (Nowacki and Abrams 2008; Arthur et al. 2012; Brose et al. 2012). Oak decline may also be apparent on lower productivity sites where shorter lived oak species are reaching older ages (Clatterbuck 1991). Many of the stands within the four oak ecozones are currently in the understory reinitation phase (Figure 32, phase 3) advancing in age and diverging in structural characteristics (Johnson et al. 2009).

It is at this stage that site productivity, in the absence of large-scale stand replacing disturbance, may create conditions favoring the encroachment of mesic species over the recruitment of oaks (Nowacki and Abrams 2008). From 1980 to 2008, the prevalence of maple species has increased annually in the eastern US including the Southern Appalachians. Over the same time period, there has been a large decrease in the prevalence of oak and hickory (Fei and Yang 2011). The historical presence of fire and past landuse facilitated the recruitment of oak into the overstory, even on more mesic sites (Nowacki and Abrams 2008; Arthur et al. 2012). On xeric sites (drier), oak recruitment more easily occurs (Arthur et al. 2012) because species like red maple and yellow poplar are not able to compete with oak (Abrams 2003). The structure and composition that develops will more likely contain oak species (Fralish 2004; Johnson 2004; Loftis et al. 2011). The resulting stand structure in dry oak ecozones may also have a dense mid-story due to the presence of brushy species like mountain laurel, a species that may not have been present prior to the fire suppression era (Brose et al. 2002; Nowacki and Abrams 2008). Dry oak and dry-mesic oak, especially on national forest lands, have midstories with densities greater than 50% (Tables 19 and 20).

With the majority of the oak ecozone landscape currently in the understory reinitiation phase, the current structural conditions may be readily modified by other light or moderate level disturbances. These disturbances may cause multiple small scale (less than 30% of the canopy disturbed, usually in small groups and individual trees) release events that enhance local structure development. More widespread, mid-level disturbance (30 to 60% canopy disturbance (Lorimer and White 2003) alters structure, creates another age class, and preserves a portion of the original overstory. Mixed-stage stands also develop where the majority of the overstory is damaged or killed leaving the development of a mosaic of wider spaced (likely grouped) old tree component with abundant regeneration of different ages (Johnson 2004). These lower density stands are usually dominated by younger growth that existed as advanced regeneration (Oliver 1981). Refer to the stressors and threats, forest health section for further discussion on disturbance.

There are large areas of the oak ecozone that have not undergone anthropogenic disturbance in the form of timber harvesting for commodity production objectives because they are in areas classified as unsuitable for timber production in the 1987 Plan. Assuming a continued lack of large scale, high intensity disturbance (removal of greater than 60% of the overstory), the existing overstory will experience declining growth rates, and insects, pests, pathogens, and small scale disturbances will take a mounting toll. The complex stage (Figure 32, phase 4) occurs as light levels increase to the point where advanced regeneration has the space and resources to advance into the remaining original canopy (Johnson 2004). Upon reaching the complex stage, gap phase dynamics dominate the forest conditions influencing both species composition and structure development. Regeneration developed in advance of disturbance (during phase 3) is now available to grow into the overstory gaps. Structure develops at the single tree crown or small group crown level (Johnson 2004). Disturbances serve to facilitate structural development with groups of old or solitary trees and gaps filled with younger trees of various ages (Johnson 2004). Oak decline is one such disturbance that has resulted in the development of complex stand structure and release of mesic species (Oak 2002). This process occurs at different locations across the stand and landscape creating the “complex” vertical and horizontal structure. Other oak ecozone disturbances are described in the stress and threats section of this assessment.

> "The normal evolution of stand structure in oak communities from even to uneven-aged eventually produces an uneven-aged collection of highly dispersed, even-aged groups of trees, each occupying a small proportion of the overall area" (Johnson 2004).

This stage commonly reaches the old growth phase when certain characteristics are achieved (Johnson 2004). However, it is not known if the development of the complex stage in the second growth forests (Nantahala and Pisgah situation included) will contain typical old growth characteristics (Johnson 2004). Comparison of the species composition within the understory to the overstory will tell the history and health of the future overstory (Johnson 2004). If the majority of seedlings and saplings present are species other than oak then the future canopy is not likely to resemble the current one.

Table 19. LiDAR-derived shrub density classes by oak-dominated ecozone and the percentage of ownership within each class (0 to 15 feet tall).

Ecozone	**Ownership**	**0 - 25 %**	**26 – 50 %**	**50 - 75 %**	**> 75%**
High Elevation Red Oak	Nantahala & Pisgah	20%	32%	27%	22%
	Non-Forest Service	23%	33%	26%	19%
Dry Oak	Nantahala & Pisgah	12%	26%	32%	29%
	Non-Forest Service	22%	31%	27%	20%
Dry-Mesic Oak	Nantahala & Pisgah	17%	30%	30%	23%
	Non-Forest Service	25%	31%	27%	17%
Mesic Oak	Nantahala & Pisgah	22%	32%	28%	19%
	Non-Forest Service	33%	34%	22%	11%

Table 20. LiDAR-derived canopy height classes for oak-dominated ecozones and the percentage of ownership within each class.

Ecozone	Ownership	< 25 Ft	26 to 50 ft	51 to 100	> 100 ft
High Elevation Red Oak	Nantahala & Pisgah	7%	32%	60%	0%
	Non-Forest Service	9%	27%	63%	1%
Dry Oak	Nantahala & Pisgah	8%	25%	63%	4%
	Non-Forest Service	14%	17%	66%	3%
Dry-Mesic Oak	Nantahala & Pisgah	7%	17%	67%	8%
	Non-Forest Service	15%	17%	64%	6%
Mesic Oak	Nantahala & Pisgah	6%	17%	70%	7%
	Non-Forest Service	16%	14%	66%	7%

Structural Differences by Oak-Dominated Ecozone: High Elevation Red Oak

Due to its presence at higher elevations, this ecozone has structural development driven more by disturbance than the other oak dominated ecozones (Lorimer and White 2003). Most notably wind, snow and ice tend to limit overstory crown height development and create canopy gaps.

Very little of the high elevation oak ecozone contains canopy heights greater than 100 feet tall (Table 21), with an average of only 14% greater than 75 feet tall.

Red oak's presence in higher numbers and basal area than other species groups in the 4 to 6 inch size classes of younger stands indicates the potential for this community to perpetuate itself during future disturbances (Figure 33). Where FIA plots have been taken in mature stands, red oak shares the main canopy with white oak and northern hardwood species. This ecozone also contains dominant northern red oak as legacy trees present on FIA plots.

Figure 33. Composite FIA plots from the high elevation red oak ecozone showing abundance and dominance of selected species groups at the onset of stem exclusion (Figure 32, phase 2).

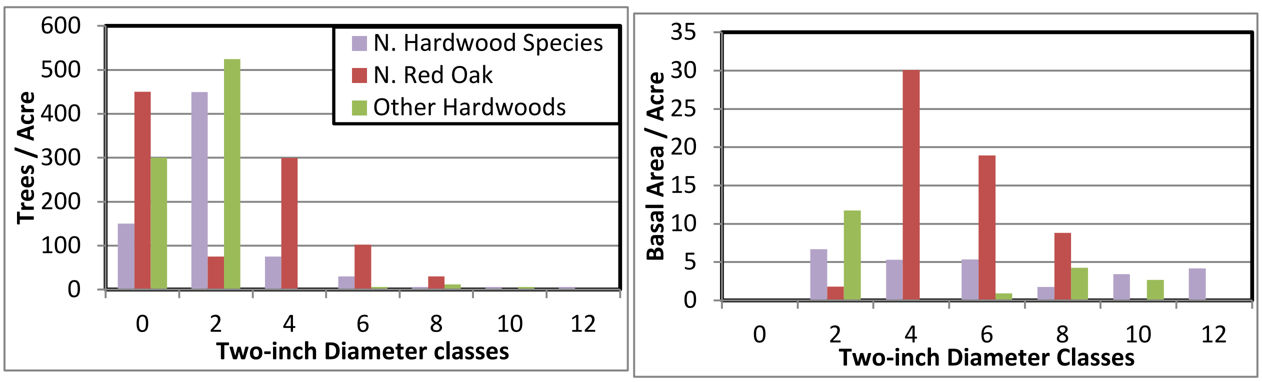


Figure 34. Composite FIA plots from the high elevation red oak ecozone showing abundance and dominance of selected species groups during stand reinitiation (Figure 32, phase 3).

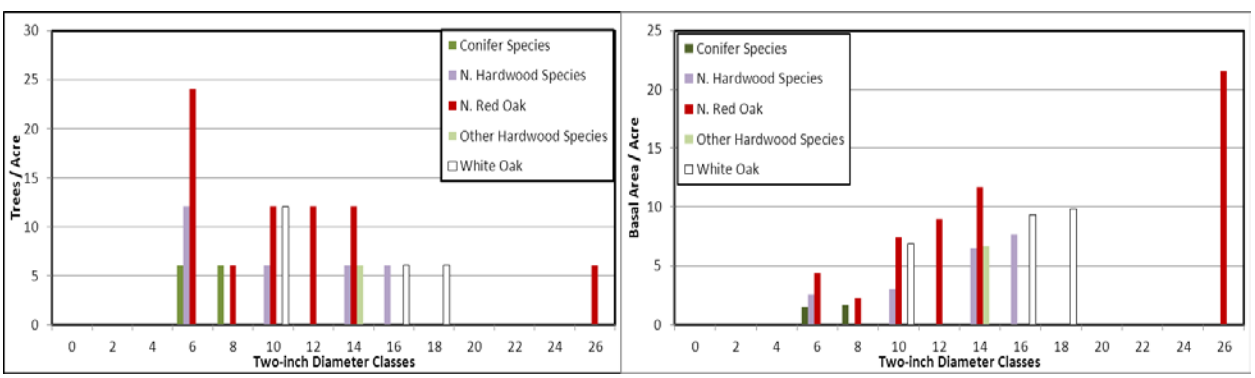


Figure 35. Stand Visualization of composite FIA plots from the high elevation red oak ecozone depicting structure during the onset of stem exclusion (Figure 32, phase 2).

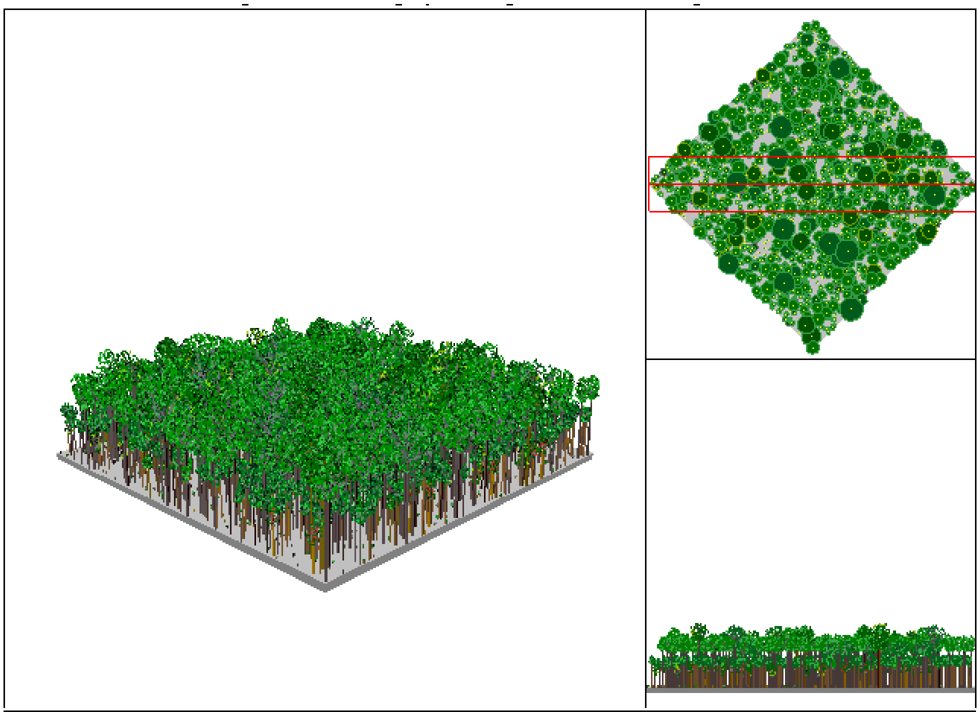
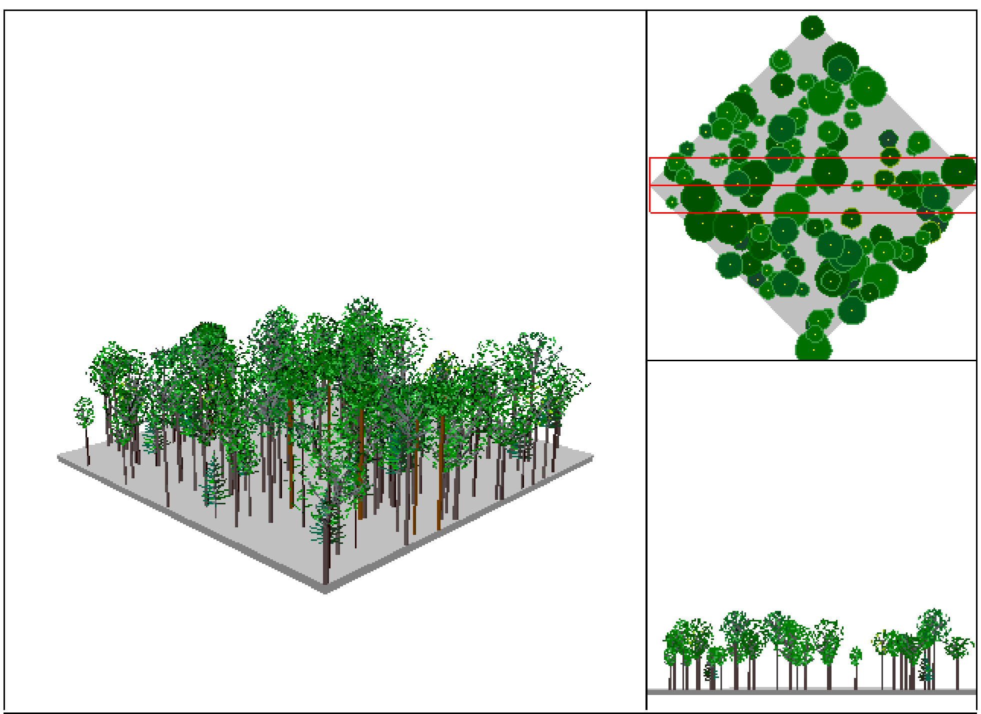


Figure 36. Stand Visualization of composite FIA plots from the dry oak ecozone depicting structure during stand reinitiation (Figure 32, phase 3).



Age Class: High Elevation Red Oak

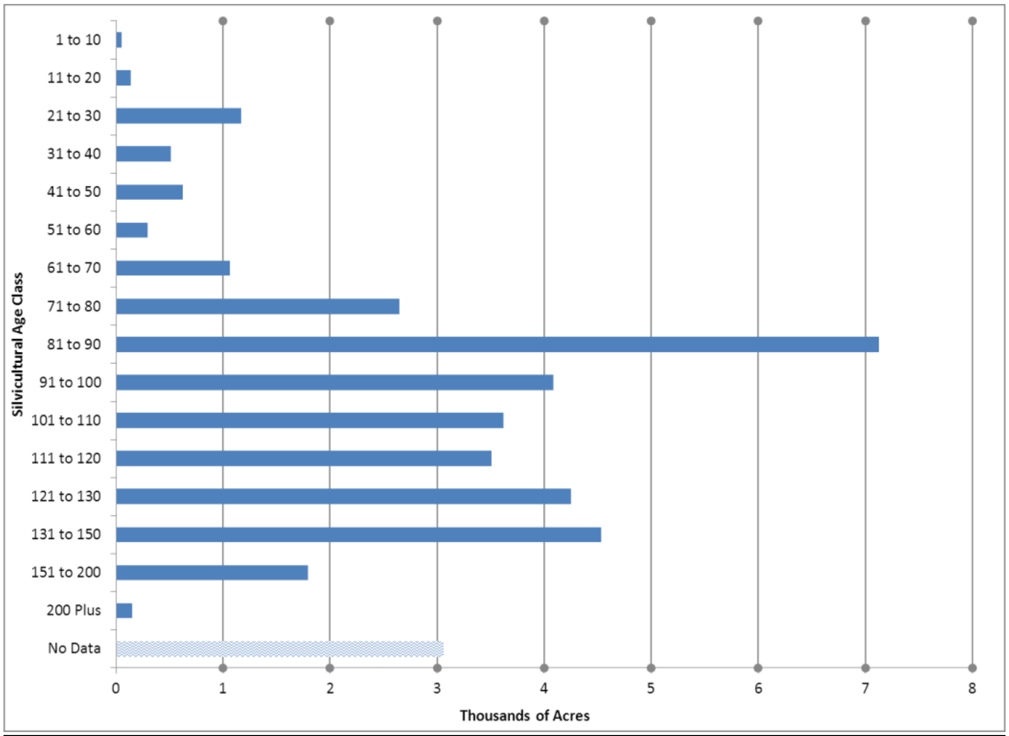
Current Silvicultural Age Class Distribution for the High Elevation Red Oak Ecozone

Low levels of management (3%) have occurred since the early 1980's. There is a higher proportion (18%) of the ecozone in age class 81 to 90; trees that grew back following the era of exploitive harvesting from the late 1800s to the 1930s. The ecozone has a large percentage (57%) of its area older than the decade that saw the most intense harvesting, 1920's (Figure 37). Approximately 17% is in older age classes, age 131 or greater.

Table 21. Nantahala & Pisgah NFs high elevation red oak current silvicultural age class distribution.

Silvicultural Age Class	Closed Acres (%)	Open Acres (%)	Total (%)
1 to 10	55 (0)	0 (0)	0
11 to 20	122 (0)	16 (0)	0
21 to 30	1,085 (3)	87 (0)	3
31 to 40	392 (1)	121 (0)	1
41 to 50	489 (1)	61 (0)	1
51 to 60	288 (1)	6 (0)	1
61 to 70	579 (1)	483 (1)	7
71 to 80	1,951 (5)	617 (2)	3
81 to 90	3,442 (9)	3,618 (9)	18
91 to 100	2,838 (7)	1,251 (3)	11
101 to 110	1,610 (4)	2,011 (5)	9
111 to 120	1,461 (4)	1,986 (5)	9
121 to 130	1,714 (4)	2,533 (7)	11
131 to 150	2,300 (6)	2,233 (6)	12
151 to 200	1,099 (3)	692 (2)	5
200 Plus	10 (0)	140 (0)	0
No Data	3,062		8
Totals	38,637		100

Figure 37. Nantahala & Pisgah NFs high elevation red oak current silvicultural age class distribution.



<u>HRV Current Age Class Distribution for the High Elevation Red Oak Ecozone</u>

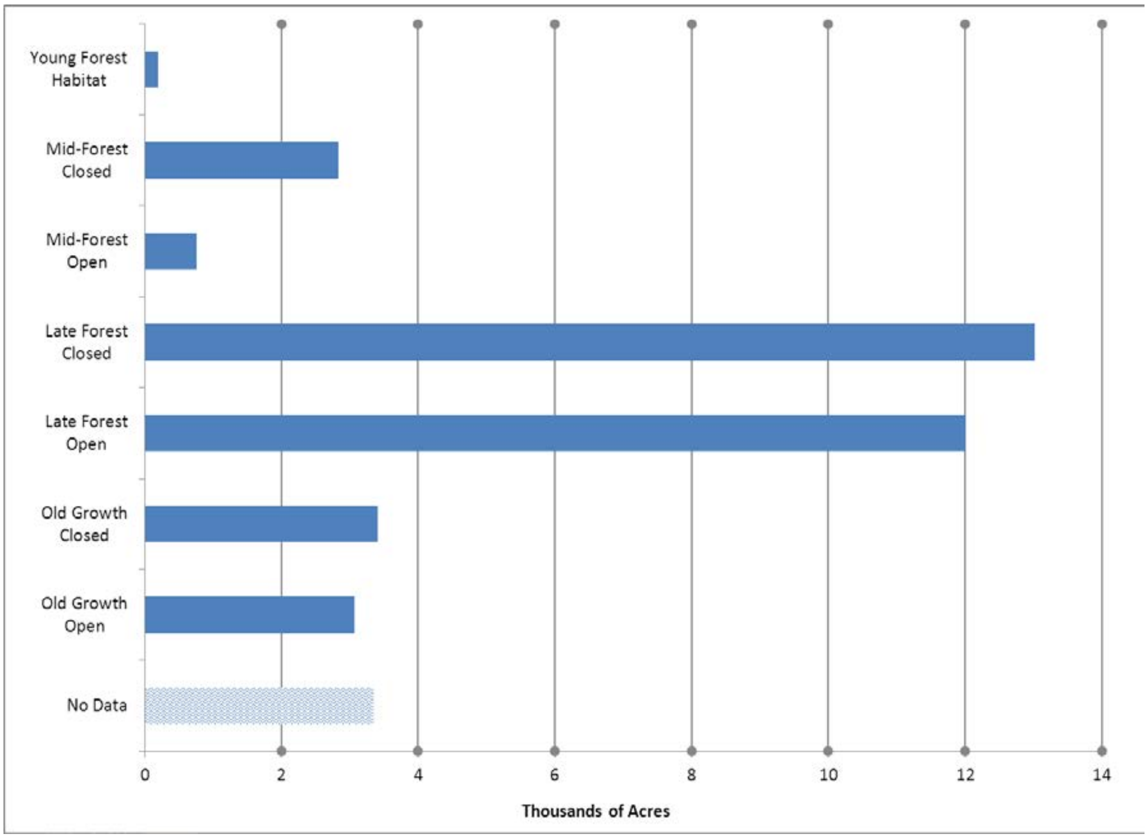
In looking at the same information from an age structure perspective, the low amount of young forest habitat created since the 1990s is still apparent. This is likely related to the fact that much of this ecozone is located in management areas that minimize vegetation management (>40% in designated areas). Those acres of the ecozone that are currently in mid-forest conditions are dominated by a closed canopy, while later and old-growth forest conditions have both open and closed conditions (Table 22). With the potentially higher level of disturbance operating in this ecozone, the presence on an increased amount of open canopy conditions late in stand development (compared to mid-forest conditions) is consistent with conventional stand dynamics (Oliver 1981; Johnson et al. 2002).

Table 22. Nantahala & Pisgah NFs high elevation red oak ecozone current BpS age structure class conditions.

Age Structure Class	Age Range	Acres	% of Total Ecozone
Young Forest Habitat	1 to 20	193	0
Mid-Forest Conditions -Closed	21 to 70	2,832	7
Mid-Forest Conditions -Open	21 to 70	759	2
Late Forest Conditions - Closed	71 to 130	13,015	34
Late Forest Conditions - Open	71 to 130	12,015	31
Old Growth Conditions - Closed	131 Plus	3,409	9
Old Growth Conditions - Open	131 Plus	3,065	8
No Data	---	3,349	9

Age Structure Class	Age Range	Acres	% of Total Ecozone
Totals	All	38,637	100

Figure 19. Nantahala and Pisgah NFs high elevation red oak ecozone current BpS age structure class conditions.



Structural Differences by Oak-Dominated Ecozone: Dry Oak Ecozone

Dry oak forests are located on sites with low productivity and may have a higher degree of disturbance than the dry-mesic oak and mesic oak ecozones. This ecozone tends to have higher structural diversity because of more light availability in the understory and ericaceous shrubs that have developed in the fire suppression era. On the lowest productivity sites, dry oak forests may have low enough overstory densities (30 - 50% crown closure) to continually let light through to the understory (Fralish 2004). The dry oak ecozone has higher shrub densities than the other three oak-dominated ecozones, especially on national forestlands. Crown heights are greater than those reported for xeric sites in the oak – hickory forest of the central hardwood forests (45 feet, Fralish 2004). For the dry oak ecozone on the Nantahala and Pisgah NFs, 63-66% of the canopy heights are in the 50 to 100 foot height class.

The generally lower productivity sites that the dry oak ecozone occupies in the forest make them less susceptible to mesic species encroachment into the understory (Abrams 2003; Fralish 2004; Nowacki and Abrams 2008; Arthur et al. 2012). Composites of FIA plots within the dry oak ecozone indicate structural development remains dominated by oak species and their tree community associates. These communities represent the most sustainable of the oak forests present on the Nantahala and Pisgah NFs, where oak species can accumulate readily in the forest understories waiting for disturbances to grow into dominant and co-dominant positions. On dry oak sites, competition from mesic species is less aggressive and their numbers don't build to such high abundances in the understory. However, mesic species are still well-represented in the understory of the FIA plots (Figure 39). Conifer species are not represented well on FIA plots in this ecozone, likely having been lost from the stand composition and structure during the southern pine beetle outbreaks in the early 1990s.

Figure 39. Composite FIA plots from the dry oak ecozone showing abundance and dominance of selected species groups at the onset of stem exclusion (A) and stand reinitiation (B) (see also Figure 32 phase 2 & 3).

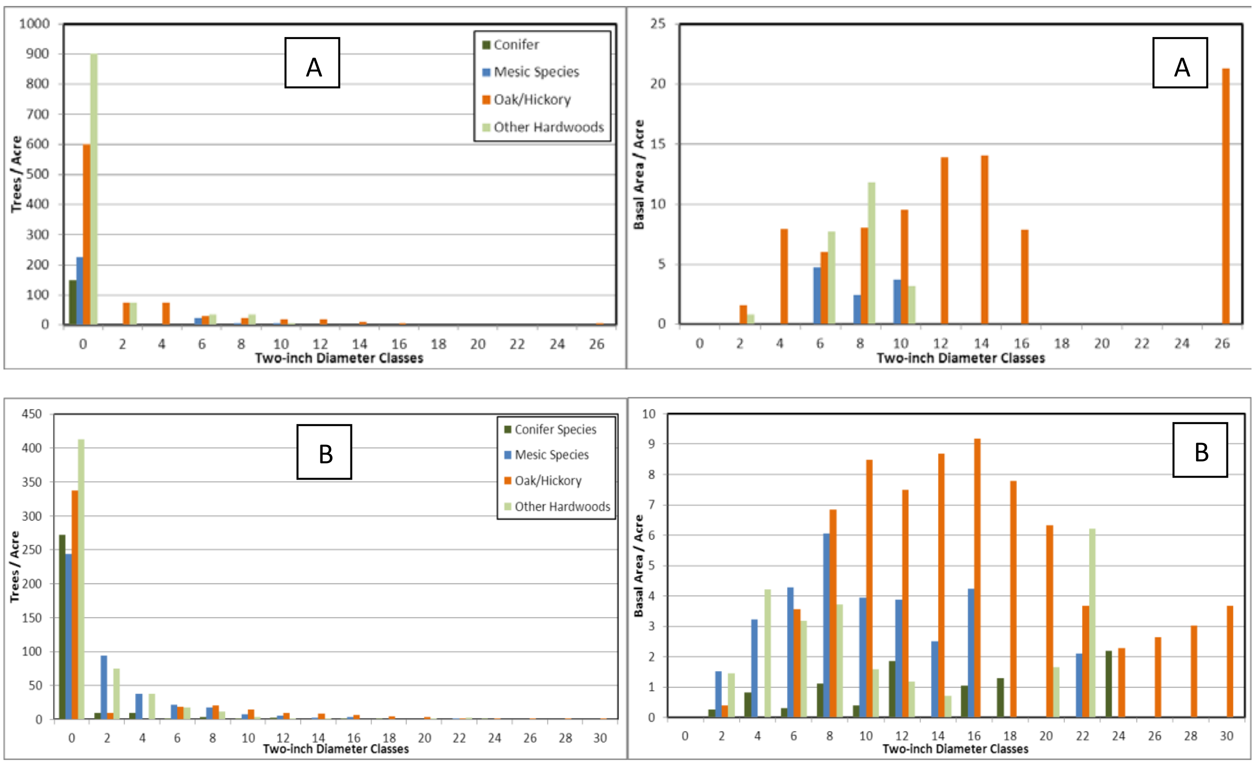


Figure 40. Stand Visualization of composite FIA plots from the dry oak ecozone depicting structure during the onset of stem exclusion (Figure 32, phase 2).

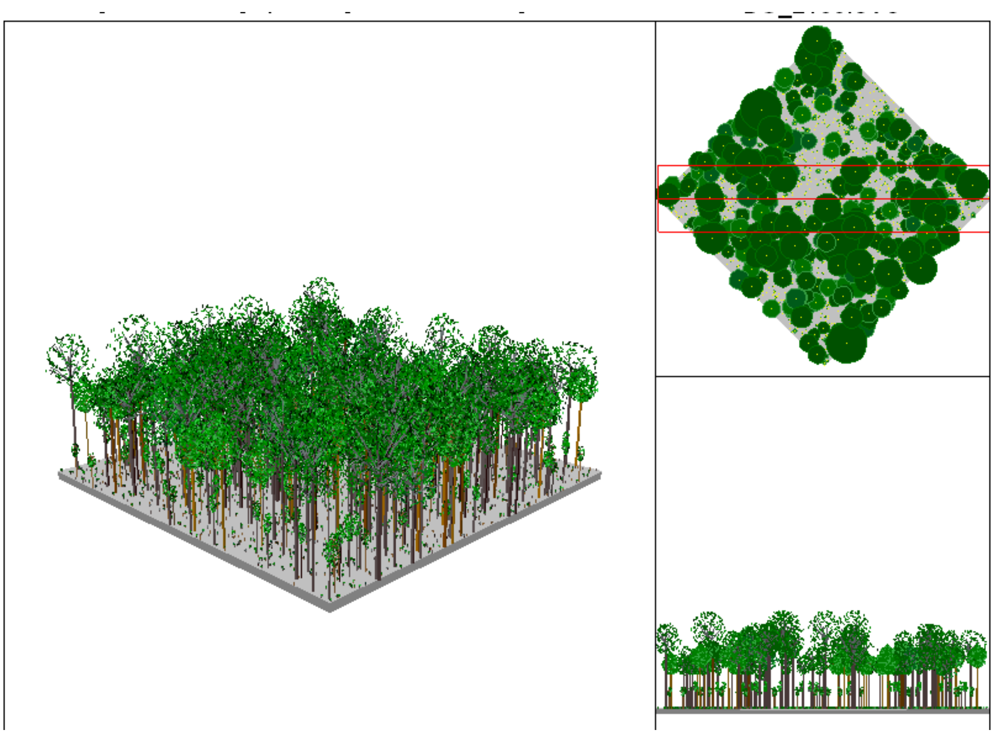
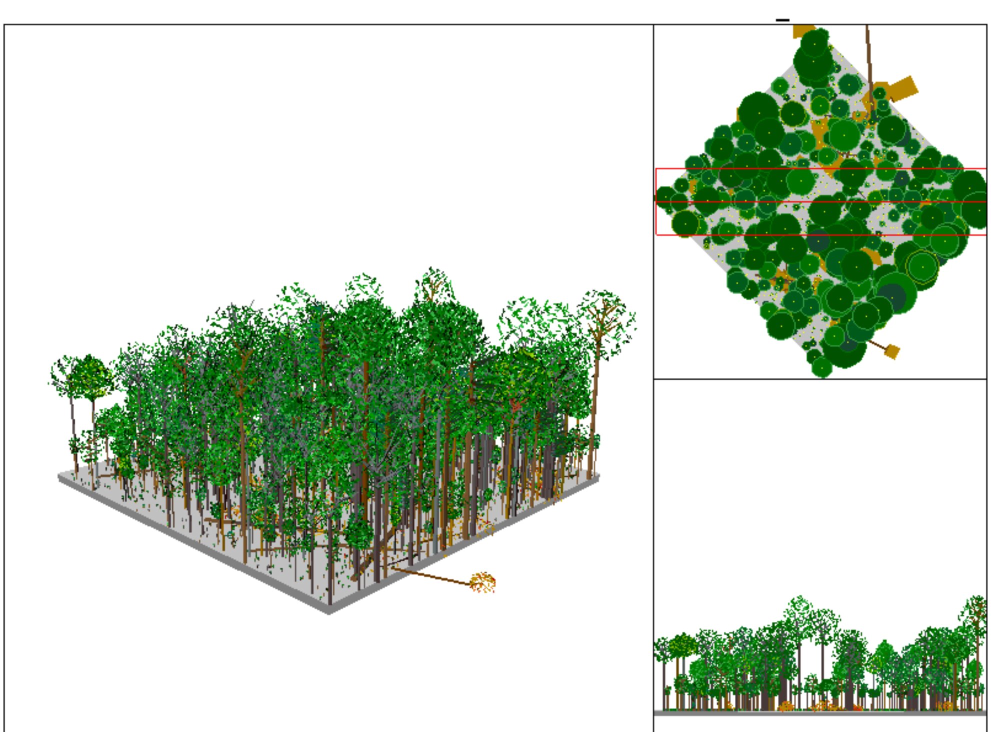


Figure 41. Stand Visualization of composite FIA plots from the dry oak ecozone depicting structure during stand reinitiation (Figure 32, phase 3).



Age Class: Dry Oak Ecozone

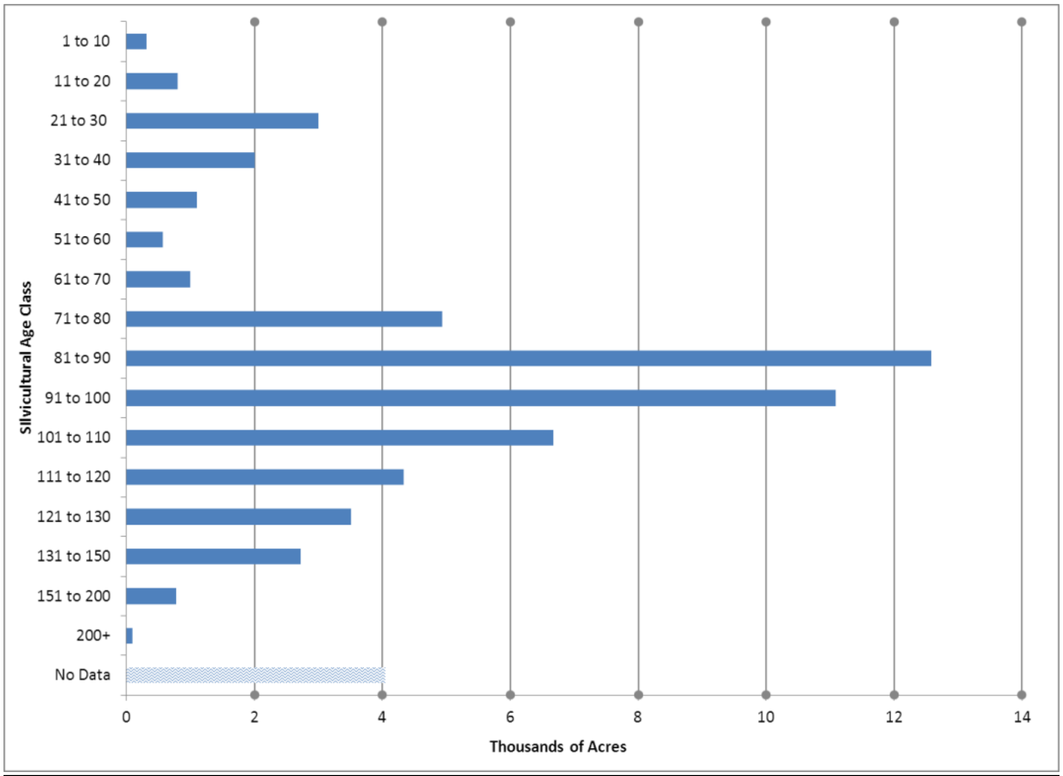
Current Silvicultural Age Class Distribution for the Dry Oak Ecozone

As with the high elevation red oak ecozone, the dry oak ecozone shows its most recent period of active management to create young forest habitat from 1973 to 1992. More recently, there has been little young forest habitat creation (Table 23). For the dry oak ecozone, the exploitive logging era and its related wildfires most influenced young forest development from 1913 to 1932, with regeneration following this indicated by those age classes with the highest percentages. Stand ages greater than 200 years are limited in this ecozone. The non-national forest lands in the dry oak ecozones contain more young forest habitat compared to national forest lands.

Table 23. Nantahala and Pisgah NFs dry oak current silvicultural age class distribution.

Silvicultural	Closed	Open	Total
Age Class	Acres (%)	Acres (%)	(%)
1 to 10	289 (0)	20 (0)	0
11 to 20	794 (1)	5 (0)	1
21 to 30	2,960 (5)	34 (0)	5
31 to 40	1,980 (3)	17 (0)	3
41 to 50	1,050 (2)	52 (0)	2
51 to 60	501(1)	70 (0)	1
61 to 70	868 (1)	137 (0)	1
71 to 80	3,871 (6)	1,029 (2)	8
81 to 90	8,860 (15)	3,727 (6)	21
91 to 100	7,918 (13)	3,154 (5)	18
101 to 110	4,005 (7)	2,669 (4)	11
111 to 120	2,192 (4)	2,106 (4)	8
121 to 130	1,642 (3)	1,869 (3)	6
131 to 150	1,248 (2)	1,479 (2)	4
151 to 200	419 (1)	360 (1)	2
200 Plus	32 (0)	60 (0)	0
No Data	4,083		7
Totals	59,584		100

Figure 42. Nantahala and Pisgah NFs dry oak current silvicultural age class distribution.



<u>HRV Current Age Class Distribution for the Dry Oak Ecozone</u>

The dry oak ecozone is dominated by closed canopy forest with the bulk of the ecozone in late forest conditions (Table 24). One percent of the dry oak ecozone is in the herbaceous and young forest habitats (Table 24). This is likely related to the relatively inaccessible location of the ecozone on the Nantahala and Pisgah landscapes. Six percent is classified as old growth, evenly split between open and closed conditions (Table 24).

In the absence of anthropogenic disturbances, like Native American and early colonial burning, the dry oak ecozone is likely to have a more dense structure throughout the canopy layers as ericaceous shrubs, associated hardwoods (dogwood, sassafras, etc), and some more drought tolerant mesic species (red maple) accrue (Abrams 1998, 2003). The open and closed canopy conditions are roughly equal for acres present with old growth ages indicating that for at least the overstory, density is dropping on these sites after roughly 120 years of growth. Though these site types display lower productivity and species mix (scarlet and black oak), they are expected to develop more heterogeneous canopy conditions by this age.

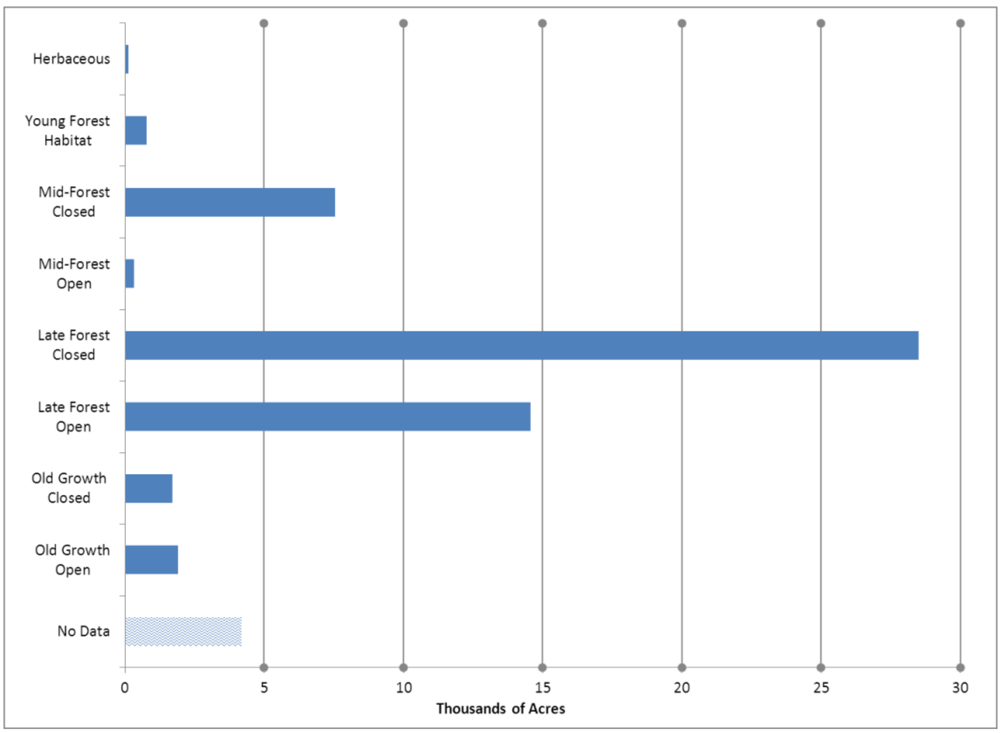
Table 24. Nantahala & Pisgah NFs dry oak ecozone current BpS age structure class conditions.

Age Structure Class	Age Range	Acres	% of Total Ecozone
Herbaceous Habitat (Grass)	1 to 3	131	0
Young Forest Habitat	4 to 19	780	1

Age Structure Class	Age Range	Acres	% of Total Ecozone
Mid-Forest Conditions –Closed	20 to 70	7,536	13
Mid-Forest Conditions –Open	20 to 70	316	1
Late Forest Conditions – Closed	71 to 100	28,489	48
Late Forest Conditions – Open	71 to 100	14,554	24
Old Growth Conditions – Closed	101 Plus	1,700	3
Old Growth Conditions – Open	101 Plus	1,899	3
No Data	---	4,180	7
Totals	All	59,548	100

The data indicates that canopy density from age classes 111 and above share comparable levels of open and closed conditions. For some species present in the canopy of this ecozone (black and scarlet oaks), this age class may be more susceptible to oak decline (Stringer, unpublished).

Figure 43. Nantahala & Pisgah NFs dry oak ecozone current BpS age structure class conditions.



Structural Differences by Oak-Dominated Ecozone: Dry-Mesic Oak

Higher levels of mesic species present in the lower size classes within this ecozone indicate the ability of mesic species to compete well on dry-mesic oak sites (Nowacki and Abrams 2008). Compared to dry oak sites, young forest habitats in the dry-mesic oak ecozone have more microsites with conditions suitable for mesic species in the absence of fire. Older stands still show oak species abundant and dominant in the main canopy but mesic species are advancing into the intermediate and co-dominant positions. An abundance of mesic species are present in the smaller size classes as the stands enter the understory reinitiation phase (Figure 32). Conifer species appear play a marginal role in the structure and composition of this ecozone.

The mesic species, having a higher shade tolerance, have added to the midstory structure on dry-mesic oak sites. In combination with the typical oak community understory tree species (sourwood, black gum, and dogwood) they form a dense midstory in many areas. On national forest lands in this ecozone, over half of the sites have shrub densities greater than 50%.

Heights identified by LiDAR are comparable with oak-hickory on similarly productive sites in the central hardwood forests, 64 – 67% of canopy heights between 50 and 100 feet vs. an average of 70 to 80 feet (Fralish 2004).

Figure 44. Composite FIA plots from the dry-mesic oak ecozone showing abundance and dominance of selected species groups at the beginning of stem exclusion (A), late stem exclusion (B), and understory reinitiation (C) (Figure 32, phases 2,3,4).

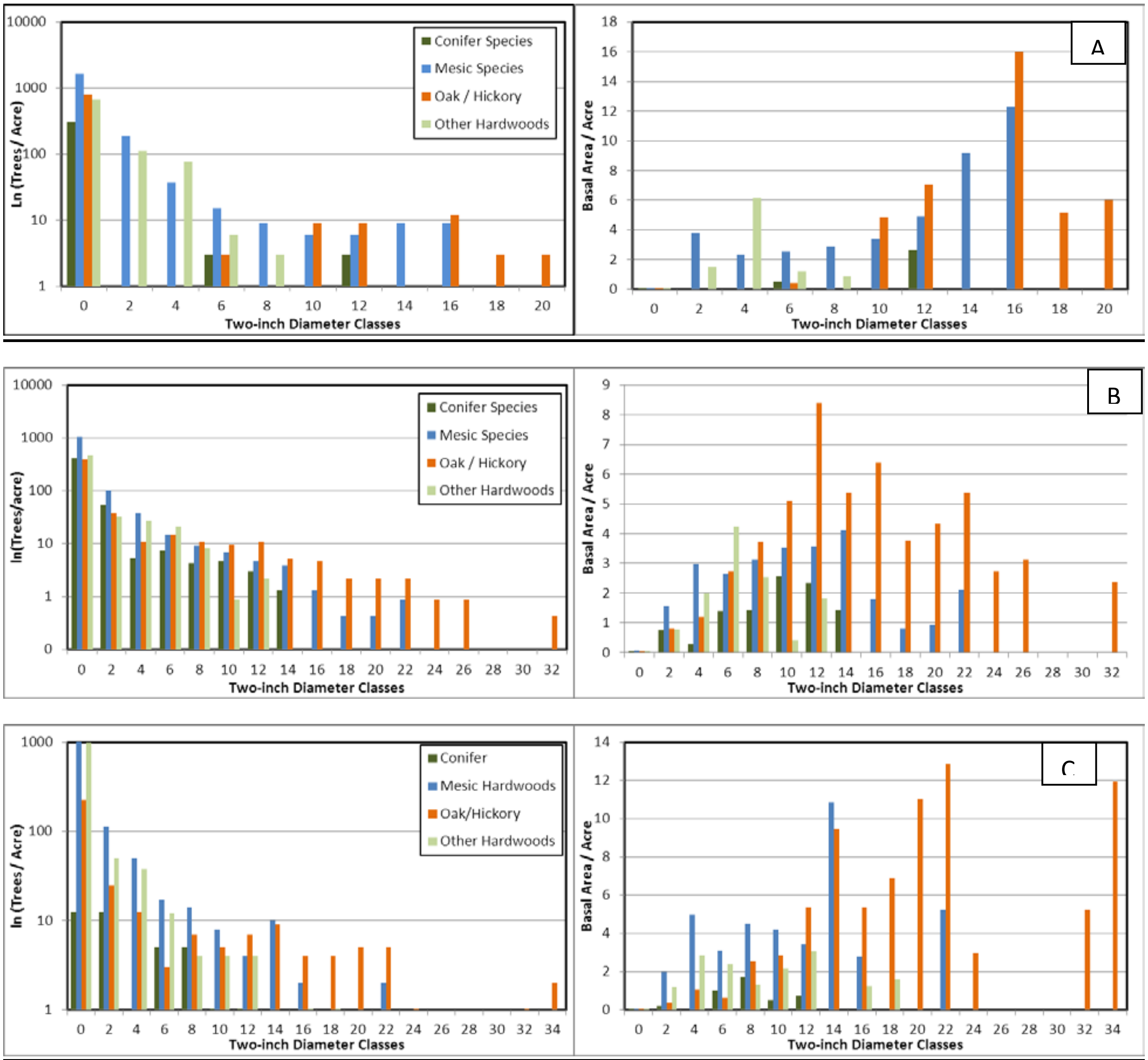


Figure 45. Stand Visualization of composite FIA plots from the dry-mesic oak ecozone depicting structure during stand reinitiation (Figure 32, phase 1).

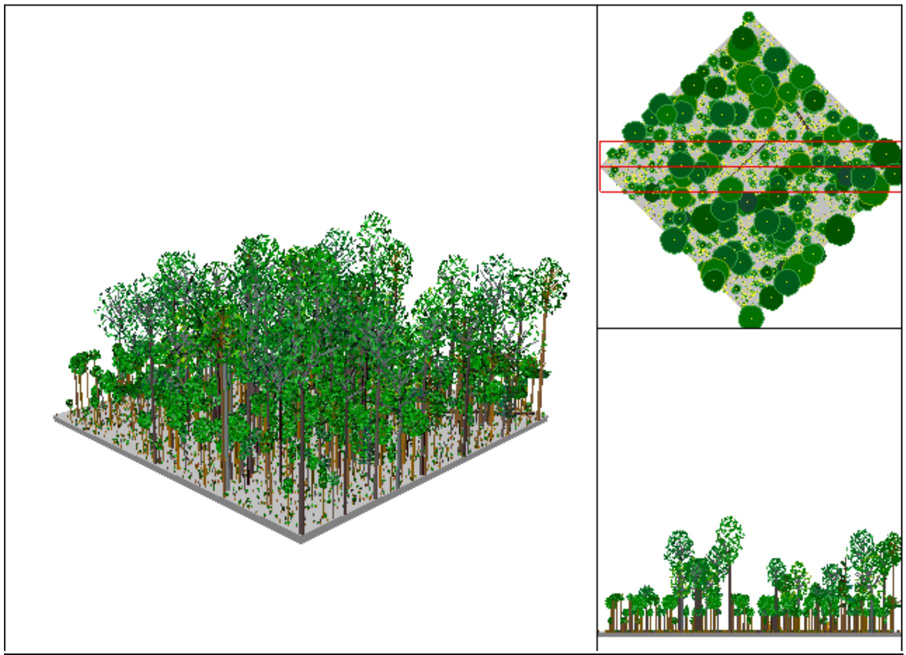


Figure 46. Stand Visualization of composite FIA plots from the dry-mesic oak ecozone depicting structure during late stem exclusion (Figure 32, phases 2,3).

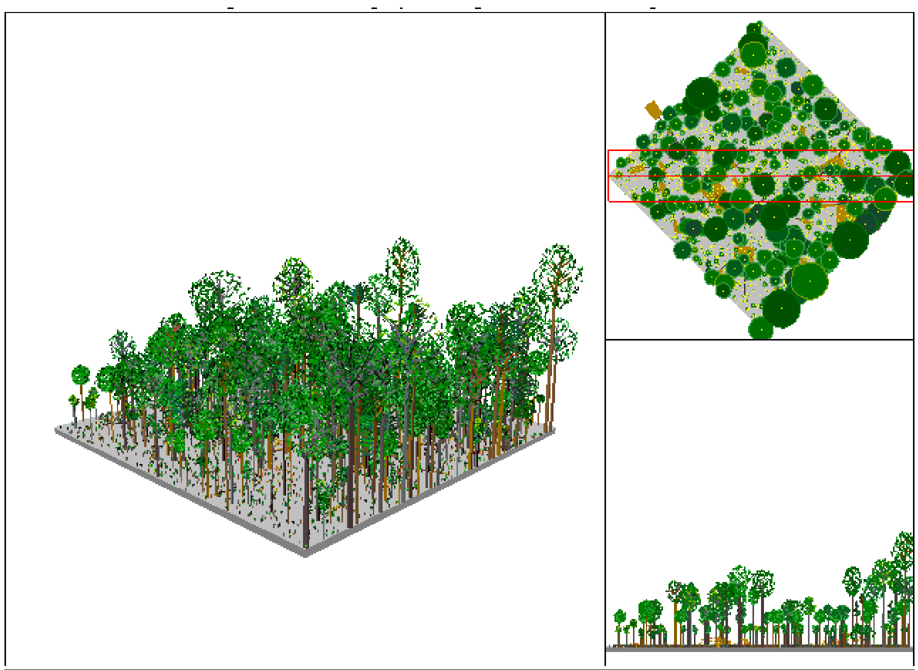
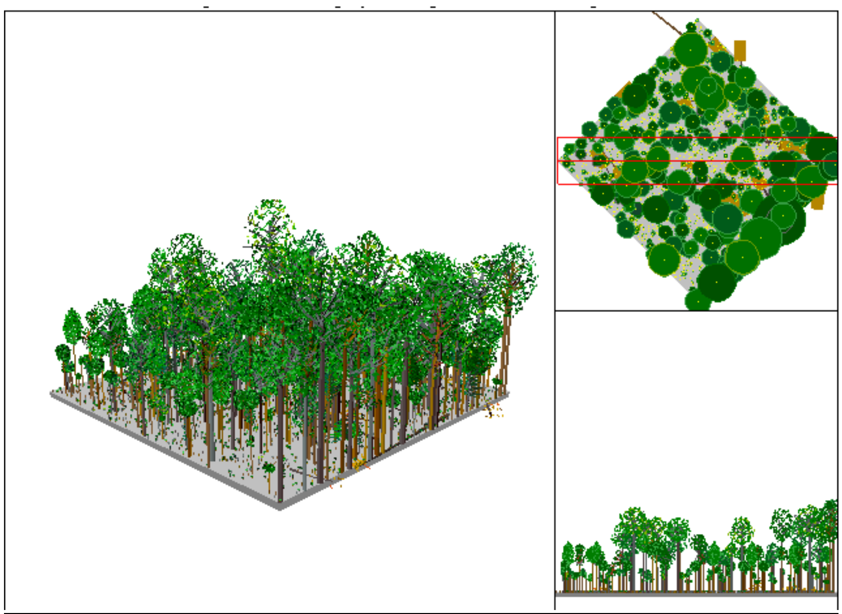


Figure 47. Stand Visualization of composite FIA plots from the dry-mesic oak ecozone depicting structure during understory reinitiation (Figure 32, phase 3).



Age Class: Dry-Mesic Oak

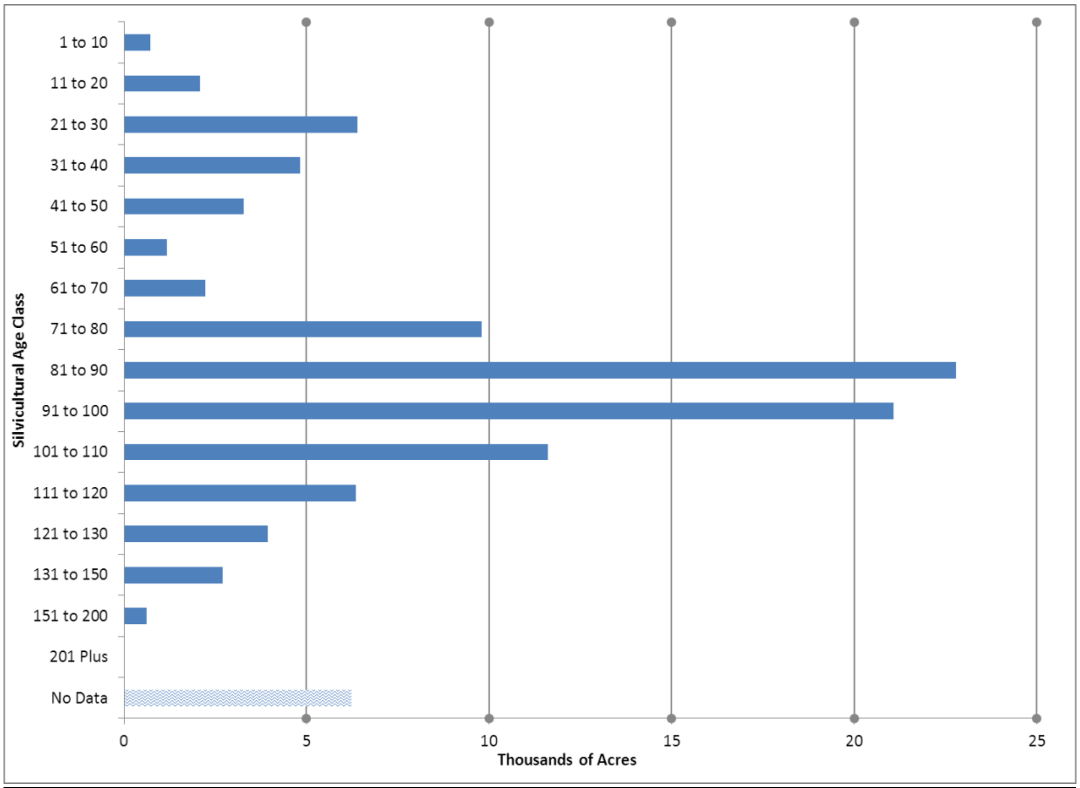
Current Silvicultural Age Class Distribution for the Dry-Mesic Oak Ecozone

Some young forest habitat has been created in the last two decades, but more was created during the period between 1973 to 1992. Lands within this ecozone were most heavily influenced by the exploitave logging and fires from 1913 to 1932 when 41% of the lands were converted to young forest habitat that has now grown to be 81-100 years. Very little forest exists older than 131 years old (Table 25), making this proportionally the youngest of the four oak-dominated ecozones.

Table 25. Nantahala & Pisgah NFs dry-mesic oak current silvicultural age class distribution.

Silvicultural Age Class	Closed Acres (%)	Open Acres (%)	Total (%)
1 to 10	700 (1)	29 (0)	1
11 to 20	2,083 (2)	3 (0)	2
21 to 30	6,370 (6)	28 (0)	6
31 to 40	4,766 (5)	26 (0)	5
41 to 50	3,179 (3)	66 (0)	3
51 to 60	1,074 (1)	95 (0)	1
61 to 70	2,074 (2)	149 (0)	2
71 to 80	8,011 (8)	1,755 (2)	10
81 to 90	17,282 (16)	5,516 (5)	21
91 to 100	14,964 (14)	6,103 (6)	20
101 to 110	7,987 (8)	3,630 (3)	11
111 to 120	4,210 (4)	2,138 (2)	6
121 to 130	2,749 (3)	1,197 (1)	4
131 to 150	1,977 (2)	720 (1)	3
151 to 200	365 (0)	243 (0)	0
200 Plus	60 (0)	19 (0)	0
No Data	6,224		6
Totals	105,861		100

Figure 48. Nantahala & Pisgah NFs dry-mesic oak current silvicultural age class distribution.



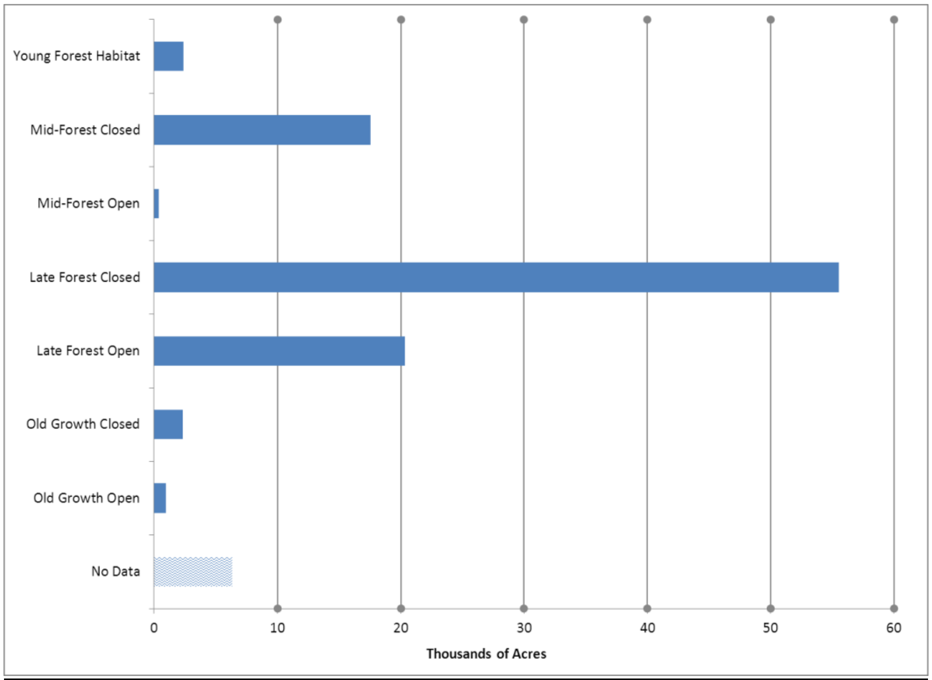
HRV Current Age Class Distribution for the Dry-Mesic Oak Ecozone

Closed conditions dominate all phases of forest community development. This is likely the result of the increased degree of mesic species encroachment on these sites occupying greater proportions of the understory and lower parts of the overstory. As with the other oak ecozones, the majority of the forest is found in the late structural conditions.

Table 26. Nantahala and Pisgah NFs dry-mesic oak ecozone current BpS age structure class conditions.

Age Structure Class	Age Range	Acres	% of Total Ecozone
Young Forest Habitat	1 to 19	2,382	2
Mid-Forest Conditions -Closed	20 to 69	17,569	17
Mid-Forest Conditions -Open	20 to 69	355	0
Late Forest Conditions - Closed	70 to 130	55,527	52
Late Forest Conditions - Open	70 to 130	20,349	19
Old Growth Conditions - Closed	131 Plus	2,349	2
Old Growth Conditions - Open	131 Plus	982	1
No Data	---	6,350	6
Totals	All	105,861	100

Figure 49. Nantahala and Pisgah NFs dry-mesic oak ecozone current BpS age structure class conditions.



Structural Differences by Oak-Dominated Ecozone: Mesic Oak

The mesic oak ecozone is the most common of the oak-dominated ecozones, and is found on some of the moderate to moderately-high productive sites on the Nantahala and Pisgah NFs. Due to the presence of higher productivities, oak communities in this zone are at the highest risk for encroachment of mesic species (Nowacki and Abrams 2008).

For composites of FIA plots taken during the stem exclusion phase, mesic species are dominant in both trees per acre and basal area. This represents the most dramatic disparity in conditions over all the oak-dominated ecozones. At these early ages, oak species do exert some dominance in the main canopy but it is with few numbers and likely of stump sprout origin. The encroachment of mesic species becomes more apparent in the older FIA composite abundance and dominance data. In the older age classes, oak basal areas are far below the level of mesic species, comprising less than 30% of the basal area. FIA plots taken in stands greater than 120 years old indicate a shift away from a forest dominated by oak as the community enters the complex stage. On these types of mesic sites, the process of succession (mesic species encroachment) will inevitably occur over the next 50 to 100 hundred or more years (Fralish 2004). Once these structural and compositional shifts occur, it may prove to be extremely difficult to restore oaks to these areas (Abrams 1998, 2003; Nowacki and Abrams 2008).

Mesic oak-hickory dominated sites in the central hardwood forest region had average heights greater (100 to 120 feet) than the mesic oak ecozone (Fralish 2004). Sixty-six to 70% of the canopy heights were between 50 and 100 feet. Heights reported by Fralish (2002) are more comparable with oak – hickory growing in the rich cove or acidic cove ecozones.

Figure 50. Composite FIA plots from the mesic oak ecozone showing abundance and dominance of selected species groups at the beginning of regeneration (A), stem exclusion (B), and understory reinitiation (C) (Figure 32, phases 1,2,4).

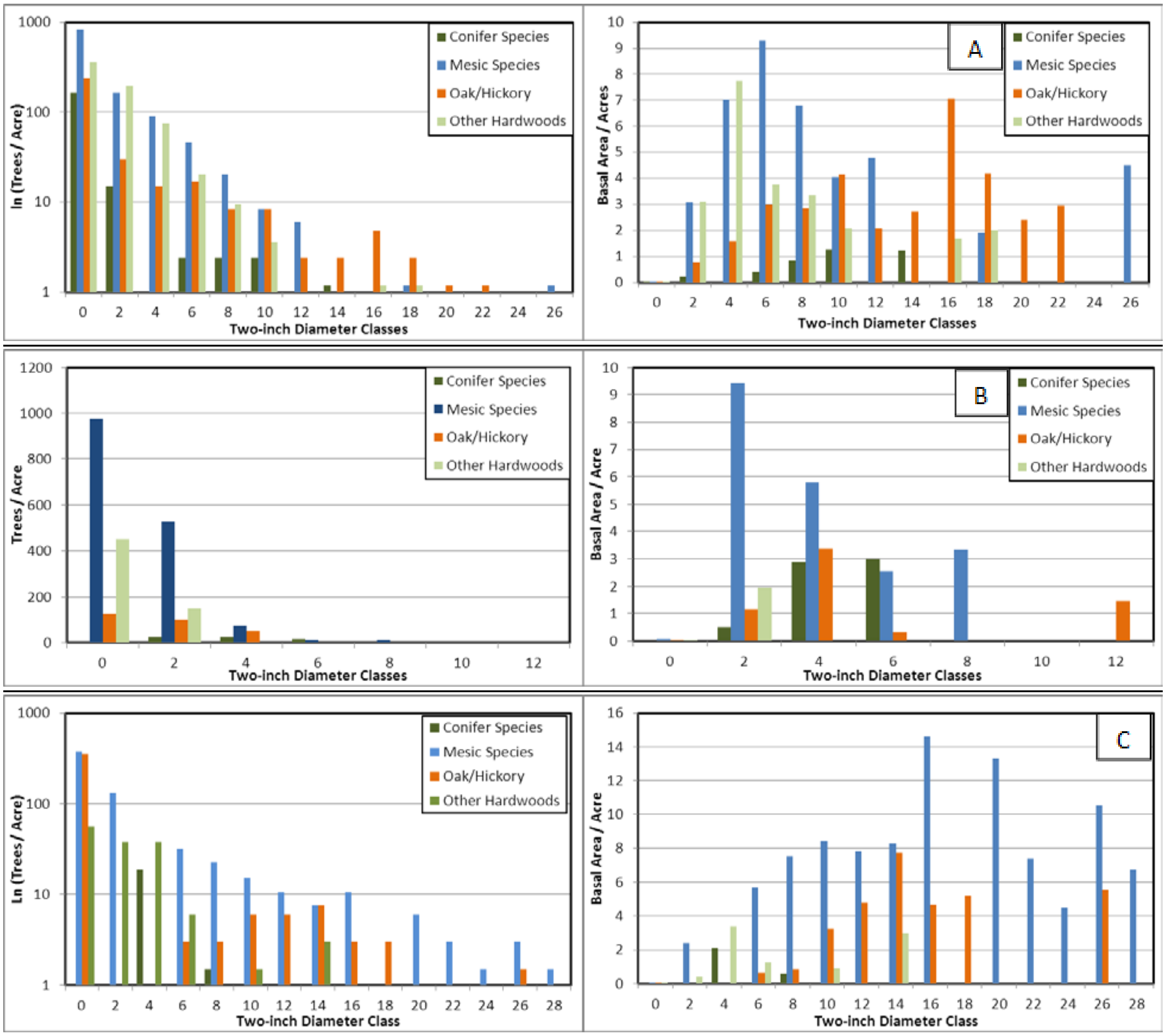


Figure 51. Stand Visualization of composite FIA plots from the mesic oak ecozone depicting structure during stand initiation (Figure 32, phase 1).

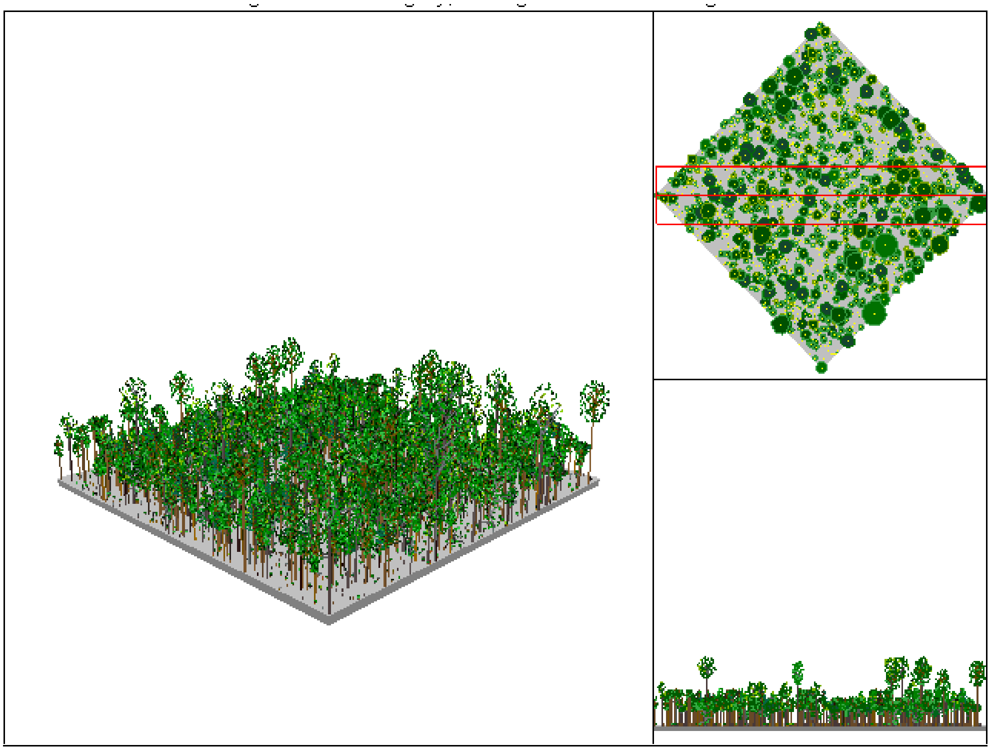
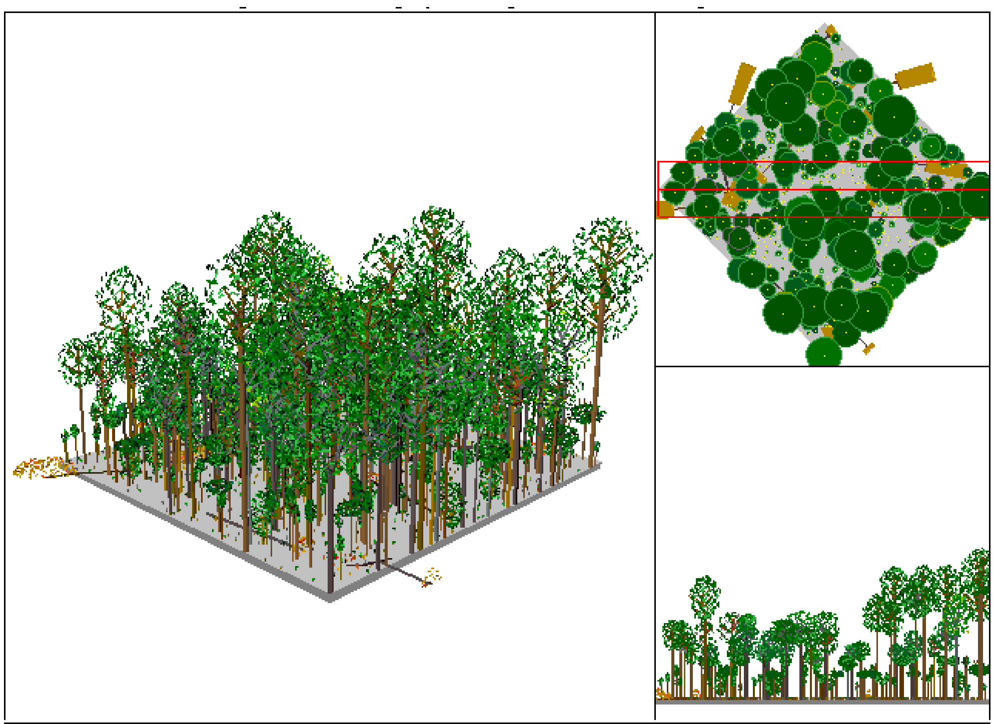


Figure 52. Stand Visualization of composite FIA plots from the mesic oak ecozone depicting structure during understory reinitiation (Figure 32, phase 3).



Age Class: Mesic Oak

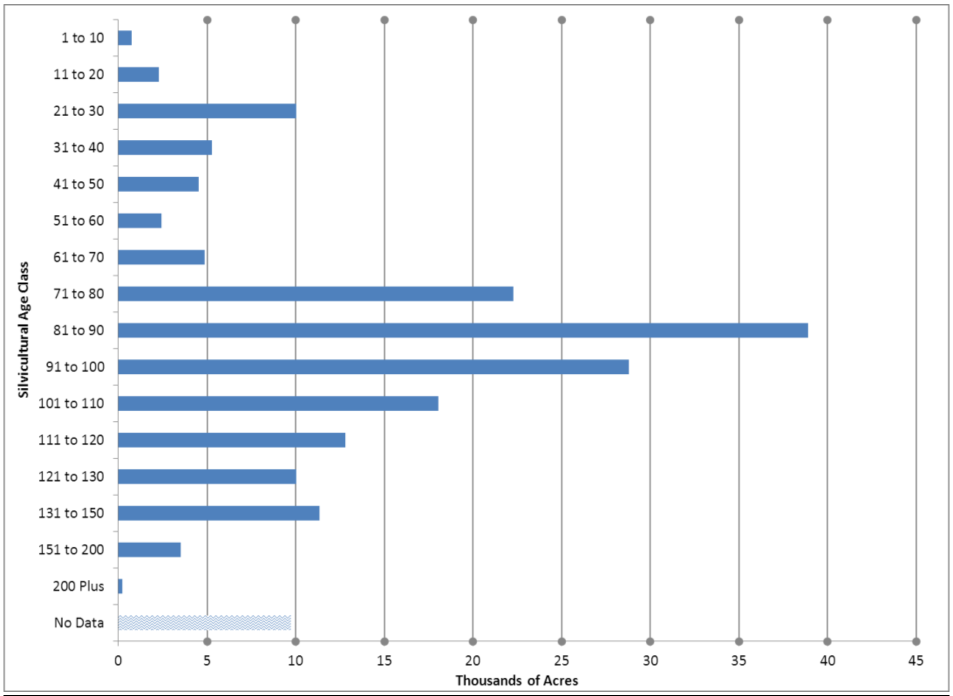
Current Silvicultural Age Class Distribution for the Mesic Oak Ecozone

The trends found in the other three oak-dominated ecozones are generally apparent within the mesic oak ecozone. A large amount of young forest was created during the exploitive logging era in the 1920s and early 1930s. of the active management occurring in the 1980s and early 1990s gave a smaller boost to creation of young forest, that has since declined. Minimal amounts of the ecozone are greater than 150 years in age (Table 27).

Table 27. Nantahala & Pisgah NFs mesic oak current silvicultural age class distribution.

Silvicultural Age Class	Closed Acres (%)	Open Acres (%)	Total (%)
1 to 10	737 (0)	5 (0)	0
11 to 20	2,263 (1)	16 (0)	1
21 to 30	9,951 (5)	80 (0)	5
31 to 40	5,203 (3)	32 (0)	3
41 to 50	4,283 (2)	153 (0)	2
51 to 60	2,333 (1)	102 (0)	1
61 to 70	4,405 (2)	461 (0)	3
71 to 80	19,009 (10)	3,180 (2)	12
81 to 90	31,546 (17)	7,105 (4)	21
91 to 100	21,782 (11)	6,995 (4)	15
101 to 110	11,690 (6)	6,322 (3)	10
111 to 120	7,359 (4)	5,388 (3)	7
121 to 130	5,542 (3)	4,498 (2)	5
131 to 150	6,120 (3)	5,277 (3)	6
151 to 200	2,611 (1)	1,227 (1)	2
200 Plus	106 (0)	110 (0)	0
No Data	9,994		5
Totals	185,858		100

Figure 53. Nantahala & Pisgah NFs mesic oak current silvicultural age class distribution.



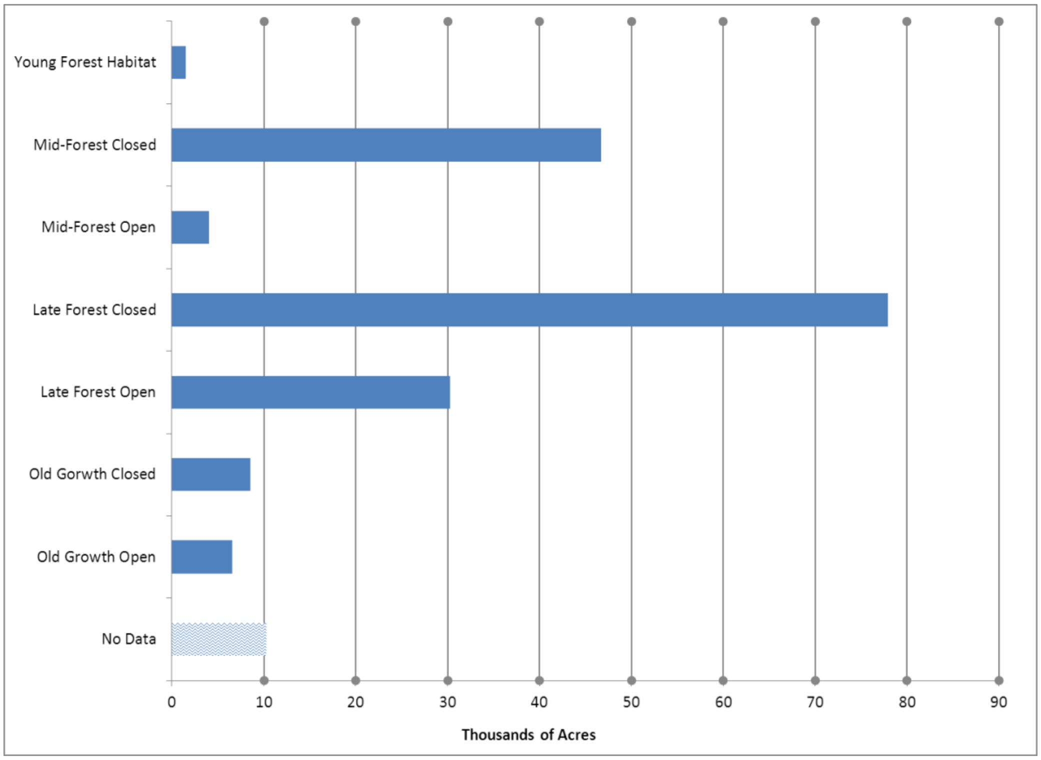
HRV Current Age Class Distribution for the Mesic Oak Ecozone

Closed late forest conditions are dominant. Higher productivity sites have allowed for the most mesic species encroachment of all the oak ecozones, leading to heavily closed canopy conditions and a shift away from oak-dominated communities.

Table 28. Nantahala and Pisgah NFs mesic oak ecozone current BpS age structure class conditions.

Age Structure Class	Age Range	Acres	% of Total Ecozone
Young Forest Habitat	1 to 15	1,484	1
Mid-Forest Conditions -Closed	16 to 80	46,708	25
Mid-Forest Conditions -Open	16 to 80	4,021	2
Late Forest Conditions - Closed	81 to 130	77,918	42
Late Forest Conditions - Open	81 to 130	30,309	16
Old Growth Conditions – Closed	131 Plus	8,538	5
Old Growth Conditions – Open	131 Plus	6,564	4
No Data	---	10,316	6
Totals	All	185,858	100

Figure 54. Nantahala and Pisgah NFs mesic oak ecozone current BpS age structure class conditions.



Oak Terrestrial Wildlife

Oak-dominated forest is the most widespread and heterogeneous habitat of the mountain region of North Carolina, and throughout the Southern Blue Ridge ecoregion. This includes mesic oak, dry-mesic oak, dry oak, and mixed pine-oak/heath ecozones. Largely because of the production of hard mast such as acorns, hickory nuts, and a variety of soft mast, the value of this habitat to wildlife is immense. In addition, different wildlife species are associated with different understory structures and compositions, including successional stages, of this forest type. Many species utilize multiple successional stages during their life cycle. When compositional and structural diversity are combined with the amount of this habitat available across the Southern Blue Ridge ecoregion, mesic oak forests become one of the most valuable wildlife habitats in the region, supporting a diverse wildlife community.

Much information is available about this community; however, this discussion focuses on landbird population trends since bird population monitoring is the largest, most reliable long-term dataset available specifically for the Nantahala and Pisgah NFs. References to other species or datasets are incorporated as appropriate. Also, a brief summary of game species harvest during the life of the existing Forest Plan is provided as an additional indicator of wildlife population trends across the Nantahala and Pisgah NFs. No analysis has been done to remove the bias associated with a changing hunter population (as referenced in other parts of this assessment). The data presented is simply a summarization of annual harvest data collected by the North Carolina Wildlife Resources Commission as it relates to the Nantahala and Pisgah NFs.

Range-wide Trends

Despite the relative abundance of mesic oak forests within North Carolina, the North Carolina Wildlife Action Plan (NCWAP) (NCWRC 2005) broadly identifies stresses on mesic oak forest as habitat loss, insects and diseases, and inappropriate management. Specifically, these include the following historic and ongoing problems:

- loss or conversion of habitats (e.g., due to human development, agriculture),
- increased development leading to greater degrees of habitat fragmentation,
- loss of embedded ephemeral pool habitats,
- chestnut blight, oak decline, gypsy moths, and other diseases/pests as they affect the composition and diversity of hardwood stands,
- fire suppression as it affects the composition, structure and diversity of hardwood stands, and
- homogeneity of stand age that has resulted in a lack of understory development.

Individual species associated with oak forest habitats may be experiencing problems other than those listed above. For example, timber rattlesnakes (*Crotalus horridus)* and other snakes are subjected to collection and persecution. Many species (e.g. cerulean warbler (*Setophaga cerulean),* golden-winged warbler (*Vermivora chrysoptera*), green salamander (*Aneides aeneus*), seepage salamander (*Desmognathus aeneus*), crevice salamander (*Plethodon longicris*) have a small range, clumped distribution, or rely on special habitats (discussed elsewhere in this assessment) making them more susceptible to stochastic or genetic population declines or local extirpations. And finally, since there is such diversity associated with oak forests, the exact habitat or life history requirements that are limiting populations of individual species may not be known.

The high percentage of public lands in the southern Blue Ridge ecoregion supporting mesic oak forests suggests that this habitat will be maintained for the long term, providing habitat for species dependent upon this forest type (Hunter et al. 1999). However, while oak forests at higher elevations provide the habitat needed to sustain populations of forest-dependent bird species, oak forests at low elevations may be more fragmented and thus may not support area-sensitive species (Hunter et al. 1999). Additionally, impacts on breeding success from forest fragmentation may be prevalent at lower elevations, especially near areas with higher human populations and more agriculture (Robinson et al. 1995). It is reasonable to assume that fragmentation effects will become more widespread as people continue to move into the region and develop land. Thus, it is important that landscape context is emphasized for the future management of mesic oak forests and the birds associated with them, especially at lower elevations.

The extent of mesic oak forest habitat is important for many bird species. Mature cove (mixed mesophytic) hardwood forests can provide important habitat for vulnerable species even in smaller stands as a result of typically having the greatest structural complexity of any southeastern forest type. In constrast, dry-mesic to dry oak-dominated forestsare not as complex and have been shown to support lower bird densities and fewer species (Katz 1997). This may be due to low amounts of open canopy or early successional habitat characteristics.

Large areas of mid- to late-successional oak forests provide suitable (and often optimal) habitat for almost every species of woodpecker, as well as many species of hawk (Hamel 1992). These areas also support large numbers of migratory and resident bird species, including wood thrush (*Hylocichla mustelina*) and ovenbird (*Seiurus aurocapilla*) in the understory, black-and-white warblers (*Mniotilta varia*) in the midstory, and scarlet tanager (*Piranga olivacea*) and eastern wood-pewee (*Contopus virens*) in the canopy (Hamel 1992; Stephenson et al. 1993; Bartlett 1995).

Riparian and floodplain stretches within mesic oak forests provide important habitat for Kentucky and hooded warblers (*Geothlypis formosa* and *Setophaga citrina*, respectively), Louisiana waterthrush (*Parkesia motacilla*) and Acadian flycatcher (*Empidonax virescens*).

In addition, grass/forb and seedling/sapling stages of mesic oak forests have been shown to provide quality habitat (nesting and foraging) for many bird species, including golden-winged, prairie and chestnut-sided warblers (*Setophaga chrysoptera*, *S. discolor*, and *S. pensylvanica*, respectively), northern bobwhite (*Colinus virginianus*), field sparrow (*Spizella pusilla*), yellow-breasted chat (*Icteria virens*) and indigo bunting (*Passerina cyanea*). Many wildlife species require multiple stages of forest succession for their life cycle habitat needs such as golden-winged warbler, ruffed grouse (*Bonasa umbellus*), and timber rattlesnakes.

To provide habitat necessary to support the myriad of species that rely upon the extent, condition and variation of Appalachian oak forests, the current proportions of early and late successional stands within the southern Blue Ridge ecoregion should be maintained and, whenever possible, augmented with appropriate disturbances reintroduced into the system (Hunter et al. 1999).

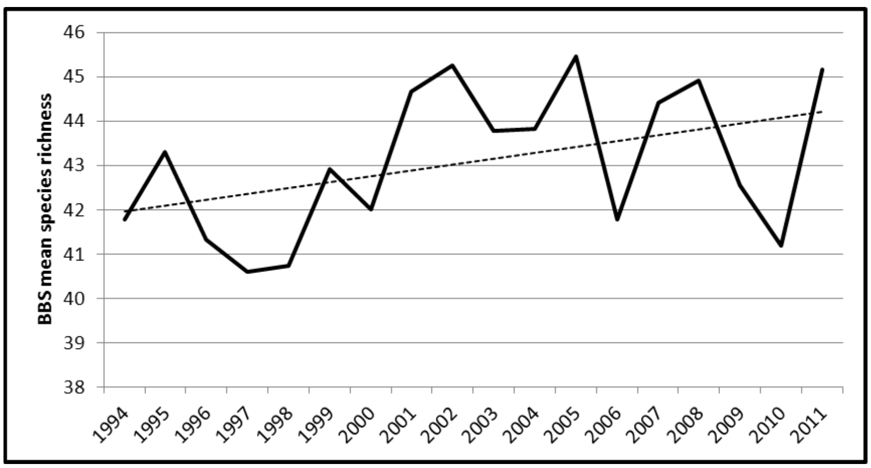
Simply put, increased structural diversity through appropriate age class distribution is necessary to conserve wildlife diversity.

Maintaining and improving healthy game bird populations is also an important issue for mesic oak forests and should be considered when plans are developed for the conservation of early successional habitat for nongame species (NCWRC 2005). Management of habitat conditions for ruffed grouse, for example, can be addressed with that of golden-winged warbler management, since there is a high degree of overlap in habitat requirements and both species have persistently low numbers. In fact, persistence of golden-winged warbler is in question in many of the same areas ruffed grouse populations are also declining (AMJV 2011).

Forest-Level Trends

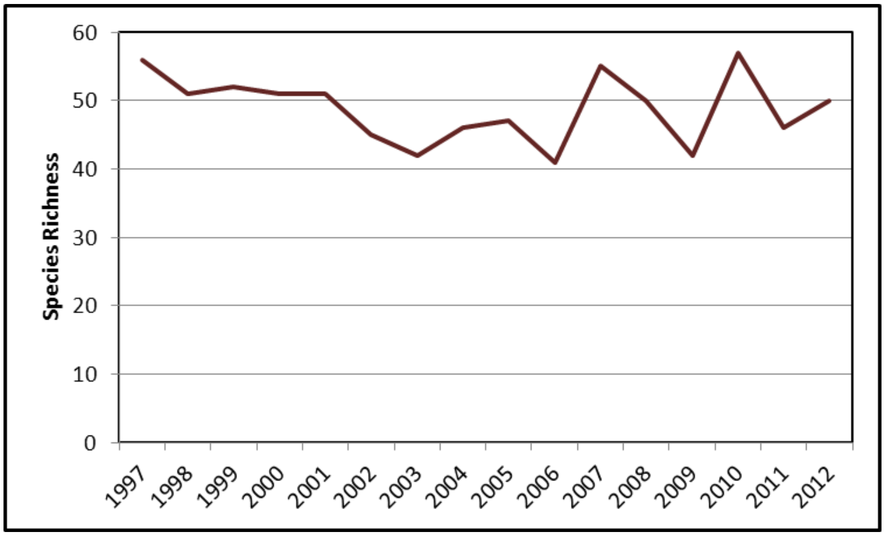
Across the Nantahala and Pisgah NFs, Breeding Bird Survey (BBS) data shows mean species richness to be stable to slightly increasing. There are seventeen established survey routes on or across the forests, thirteen of which have consistent data. Most of these routes traverse mesic oak and mixed pine-oak forests. This positive trend does not necessarily correlate to positive trends for individual species (Figure 55).

Figure 55. Mean bird species richness from Breeding Bird Survey routes on or across the Nantahala and Pisgah NFs, 1994 through 2011 (USGS 2012).



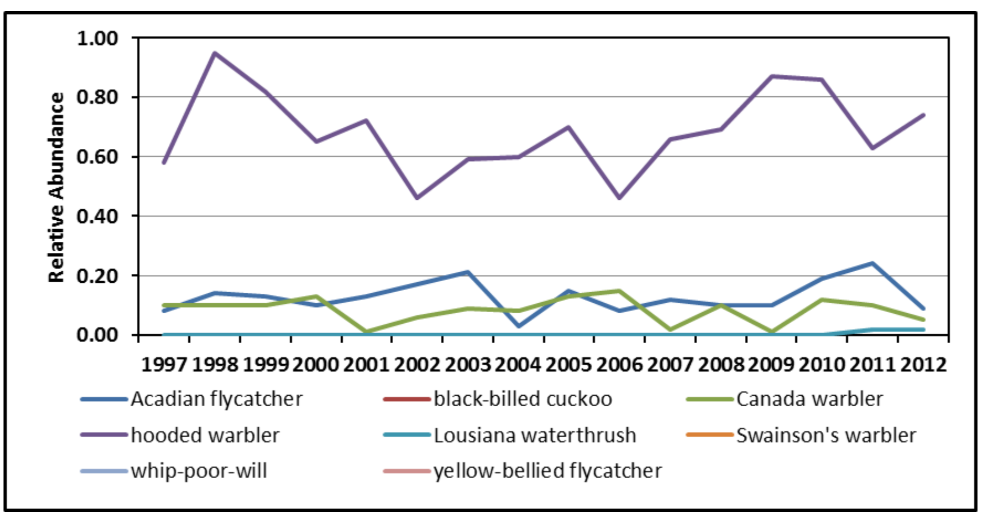
Eighty-eight bird species have been documented in mesic oak forests in the Nantahala and Pisgah NF between 1997 and 2012 (Appendix A). Within this same monitoring period, bird species richness has remained relatively stable, although annual variability is evident (Figure 56).

Figure 56. Bird species richness within mesic oak forests on the Nantahala and Pisgah NFs, 1997-2012 (USFS 2013).



The Appalachian Mountain Joint Venture (AMJV) identified six of the nine "highest conservation priority" birds as associated with mesic oak forest, from early succession to mature stands, including cerulean warbler, golden-winged warbler, Kentucky warbler, prairie warbler, wood thrush, and worm-eating warbler (AMJV 2012). Additionally, eight of the sixteen "high conservation priority" landbirds of the AMJV have habitat relationships with mesic oak forest, including Acadian flycatcher, black-billed cuckoo, Canada warbler, hooded warbler, Louisiana waterthrush, Swainson's warbler, whip-poor-will, and yellow-bellied flycatcher (AMJV 2012). Of these fourteen species, eight are known from the Nantahala and Pisgah NFs, although black-billed cuckoo, Swainson's warbler, whip-poor-will, and yellow-bellied flycatcher occur at densities too low to be accurately displayed (Figure 57).

Figure 57. Trends in AMJV highest and high conservation priority bird species associated with montane oak forests on the Nantahala and Pisgah NFs, 1997-2012 (USFS 2013).



Populations of Acadian flycatcher, Canada warbler, and Louisiana waterthrush, while at low densities, are stable within mesic oak forests on the Nantahala and Pisgah NFs. Hooded warblers occur at slightly higher, but still relatively low, densities and also exhibit stable trends, but perhaps with more annual variability (Figure 57).

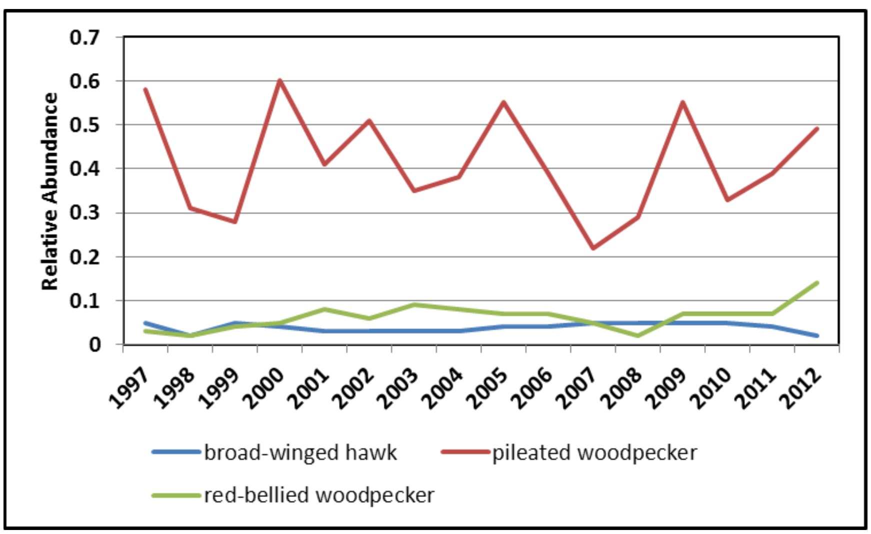
As mentioned earlier, mesic oak forest, including those mixed with pine species, is the most widespread and heterogeneous habitat of the mountain region of North Carolina, and throughout the Southern Blue Ridge ecoregion. Largely because of the production of hard and soft mast, the value of this habitat to wildlife is immense. Also, different wildlife species are associated with different understory structures and compositions, including successional stages, of this forest type and some even utilize multiple successional stages during their life cycle. The discussion below addresses trends in wildlife populations, represented primarily by bird data, associated with these key habitat characteristics.

Snags and mid- to late-successional forests

Long-term monitoring data (USFS 2013) includes three bird species identified in the Partners in Flight Bird Conservation Plan for the Southern Blue Ridge (Hunter *et al*. 1999) associated with mesic oak forests that depend on snags and other characteristics associated with mid- to late-successional forests. These species include pileated woodpecker **(***Dryocopus pileatus*), red-bellied woodpecker (*Melanerpes carolinus*) and broad-winged hawk (*Buteo platypterus*).

Populations of red-bellied woodpecker and broad-winged hawk, while at low densities, are stable to slightly increasing within mesic oak forest on the Nantahala and Pisgah NFs. Populations of pileated woodpecker are decreasing slightly within mesic oak forests and exhibit high annual variability (Figure 58).

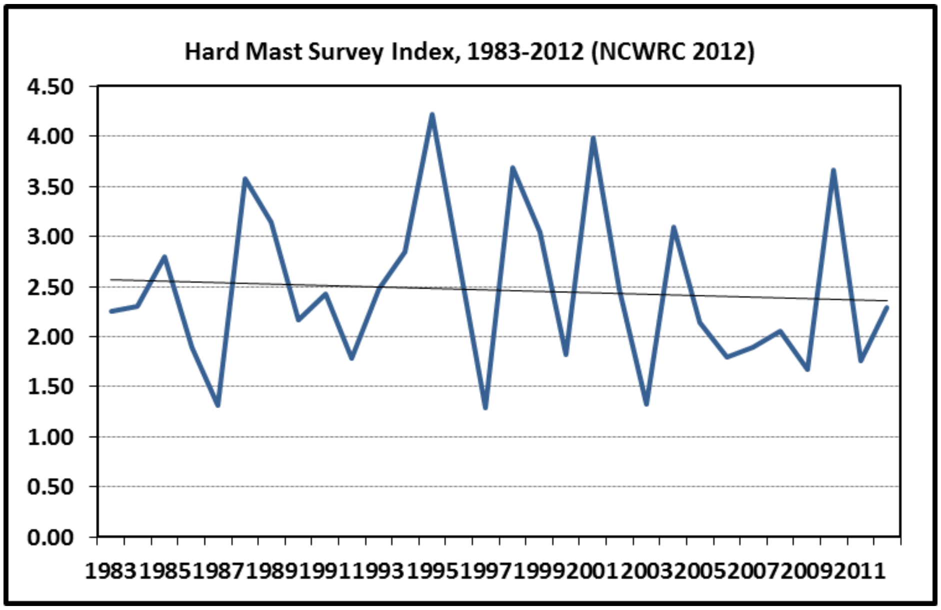
Figure 58. Relative abundance of bird species associated with mid- to late successional characteristics (e.g. snags) of mesic oak forests, 1997 through 2012 (USFS 2013).



Of related importance is the trend in hard mast production across the Nantahala and Pisgah NFs. Hard mast production peaks in mid-successional forest conditions. In addition to the bird species discussed above, many wildlife species depend on hard mast as an important food source (e.g.

wild turkey, black bear, etc.). While such species may not depend solely on hard mast production, a significant portion of their diet is dependent on this food source to be in proximity to other habitat requirements. This parameter speaks specifically to the importance of forest composition on wildlife diversity and population stability.

Figure 59. Hard mast survey index on the Nantahala and Pisgah NFs, 1983-2011 (NCWRC 2012).

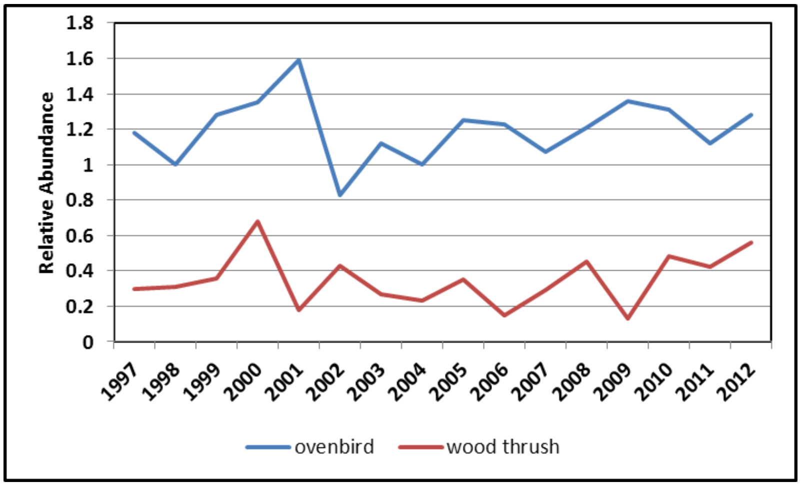


Hard mast production exhibits a very slightly decreasing (although likely not statistically significant) trend across the Nantahala and Pisgah NFs, with very high annual variability (Figure 59). This highlights that forest diversity, both at the stand and landscape levels, is vitally important to wildlife populations.

Understory vegetation

Long-term monitoring data (USFS 2013) includes two priority bird species identified in the Partners in Flight Bird Conservation Plan for the Southern Blue Ridge (Hunter et al. 1999) associated with montane oak forests that are strongly associated with understory vegetation. These species include wood thrush and ovenbird. Additionally, wood thrush is identified as a priority species associated with mesic oak forest in the NCWAP (NCWRC 2005).

Figure 60. Relative abundance of bird species associated with understory vegetation within montane oak forests, 1997 through 2012 (USFS 2013).

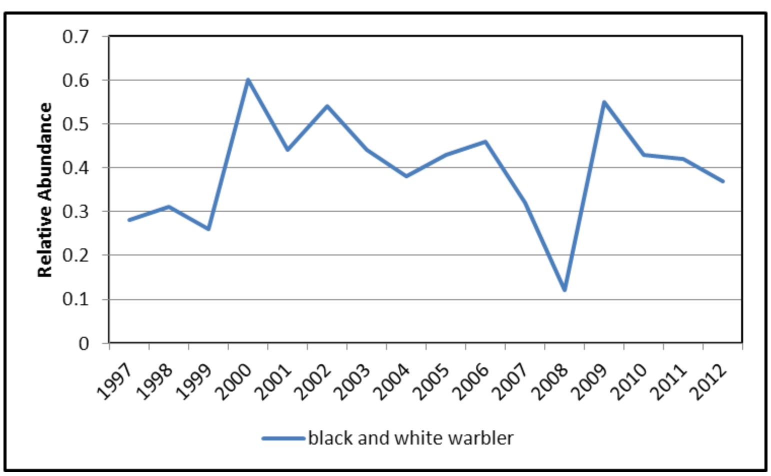


Population trends of these species are stable to slightly increasing within montane oak forests on the Nantahala and Pisgah National Forests (Figure 60). It is important to note that these species, especially the wood thrush, have experienced dramatic declines across North Carolina, largely in part to increased development on private land (Weeks, personal communication, June 25, 2013).

Midstory vegetation

Long-term monitoring data (USFS 2013) includes one priority bird species identified in the Partners in Flight Bird Conservation Plan for the Southern Blue Ridge (Hunter et al. 1999) associated with mesic oak forests that depends on midstory vegetation, the black and white warbler. Populations of this species have remained stable, despite high annual variability, on the Nantahala and Pisgah NFs over the 16-year monitoring period (Figure 61).

Figure 61. Relative abundance of bird species associated with midstory vegetation within montane oak forests, 1997 through 2012 (USFS 2013).

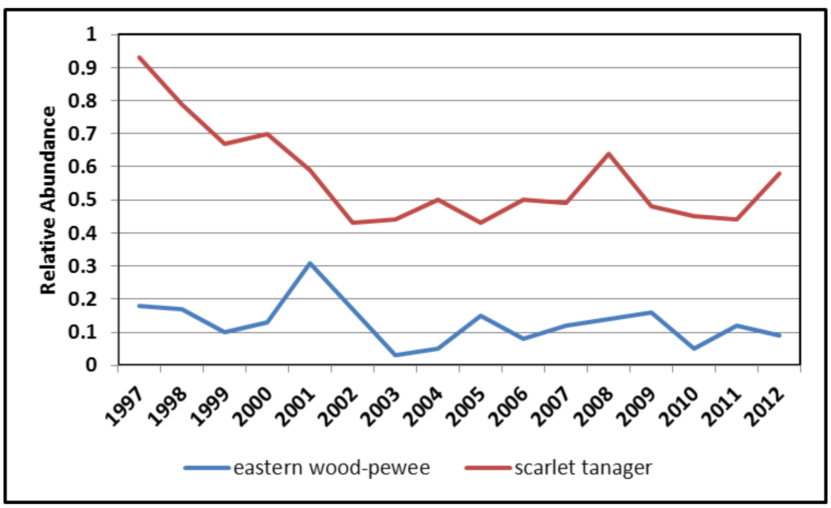


Intact tree canopy

Long-term monitoring data (USFS 2013) includes two priority bird species identified in the Partners in Flight Bird Conservation Plan for the Southern Blue Ridge (Hunter et al. 1999) associated with mesic oak forests that depend on intact canopy vegetation. These species include scarlet tanager and eastern wood-pewee. The NC Wildlife Action Plan (NCWRC 2005) identifies the eastern wood-pewee and cerulean warbler (*Setophaga cerulea*) as priority species associated with intact canopy conditions within mesic oak forest.

Cerulean warblers occur in such low numbers within mesic oak forests on the Nantahala and Pisgah NFs that population trends cannot be accurately displayed. This may be, at least in part, an artifact of the sampling design for R8Bird. R8Bird is a regional database, and there may not be enough sites within habitats suitable for cerulean warblers within North Carolina (i.e. these sites were randomly chosen from suitable habitats within other National Forests). Largely because they occur at naturally-low densities (i.e. are "rare"), cerulean warblers have been identified as a potential Species of Conservation Concern during this plan revision process.

Figure 62. Relative abundance of bird species associated with intact canopy conditions within mesic oak forests, 1997 through 2012 (USFS 2013).

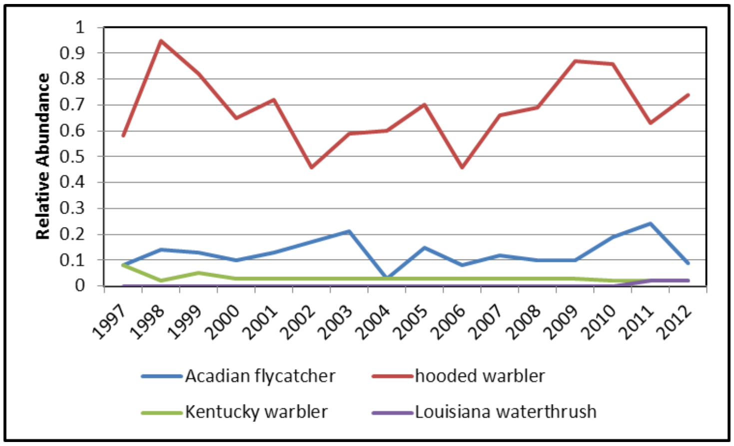


Populations of eastern wood-pewee and scarlet tanager have declined within mesic oak habitats (Figure 62) over the 16-year monitoring period. At least part of this decline may be attributable to sampling bias. R8bird is designed to monitor the effects of vegetation management on landbird populations. As such, a majority of the permanent monitoring sites are within managed areas where intact canopy conditions may not be the objective.

Riparian and streamside vegetation

Long-term monitoring data (USFS 2013) includes four priority bird species identified in the Partners in Flight Bird Conservation Plan for the Southern Blue Ridge (Hunter et al. 1999) associated with riparian and streamside conditions within mesic oak forests. These species include hooded warbler, Kentucky warbler, Acadian flycatcher, and Louisiana waterthrush. Additionally, hooded warbler and Kentucky warbler are identified as a priority species associated with riparian characteristics within mesic oak forest in the NC Wildlife Action Plan (NCWRC 2005).

Figure 63. Relative abundance of bird species associated with riparian conditions within montane oak forests, 1997 through 2012 (USFS 2013).



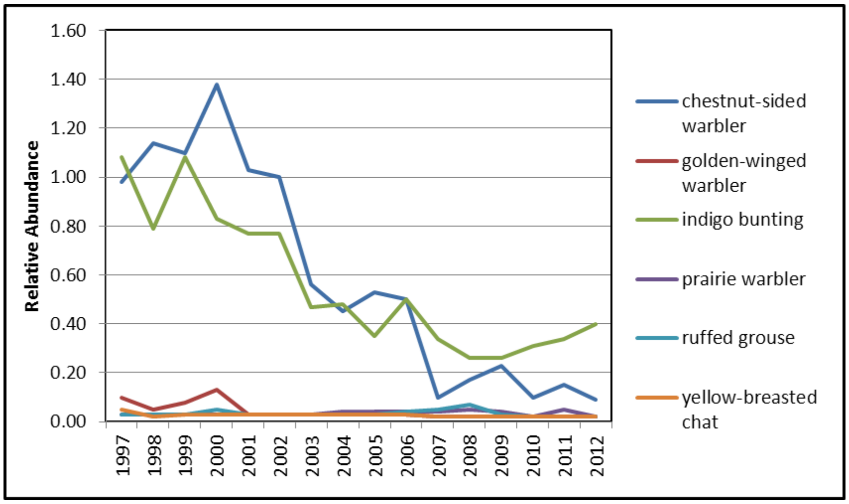
Population trends of riparian-associated bird species appear to be stable to slightly increasing over the long-term within mesic oak forests. Hooded warbler populations, occurring at much higher densities than the other riparian species in this report, exhibited higher variability during the 16-year monitoring period. Louisiana waterthrush was not detected during the monitoring period until 2006 and has increased slightly since then, despite occurring at extremely low densities (Figure 63).

Early successional and young forest conditions

Long-term monitoring data (USFS 2013) includes eight priority bird species identified in the Partners in Flight Bird Conservation Plan for the Southern Blue Ridge (Hunter et al. 1999) associated with mesic oak forests that depend on early successional and young forest conditions. These species include the chestnut-sided warbler, golden-winged warbler, northern bobwhite, yellow-breasted chat, field sparrow, indigo bunting, prairie warbler, and ruffed grouse. The golden-winged warbler is identified as a priority species associated with early successional and young forest characteristics within mesic oak forest in the NC Wildlife Action Plan (NCWRC 2005). Additionally, ruffed grouse are of conservation interest since the species is managed as a game species by the NCWRC. Field sparrows and northern bobwhite do not occur in high enough numbers across the Nantahala and Pisgah NFs to be included in Figure 64. Largely because they occur at low densities (i.e. are “rare”) or have experienced dramatic population declines, golden-winged warblers and ruffed grouse have been identified as potential Species of Conservation Concern (SCC) during this plan revision process.

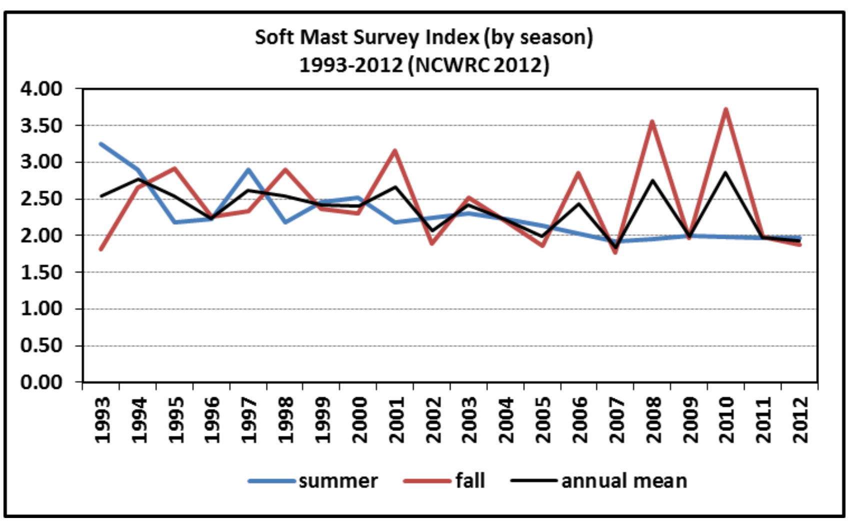
Golden-winged warblers, ruffed grouse, and yellow-breasted chat occur at low densities, but have been relatively stable within mesic oak habitats. Ruffed grouse populations have remained stable over the last 10 years based on drumming surveys conducted by the NCWRC, however, there is strong evidence that ruffed grouse populations declined on the Nantahala and Pisgah NFs from the 1980s to the 1990s (NCWRC 2013). Populations of chestnut-sided warblers and indigo buntings have declined dramatically over the sixteen-year monitoring period (Figure 64).

Figure 64. Relative abundance of bird species associated with early successional and young forest characteristics of mesic oak forests, 1997 through 2012 (USFS 2013).



Of related importance is the trend in soft mast production across the Nantahala and Pisgah NFs. Soft mast production peaks in young forest and early successional conditions. In addition to the bird species discussed above, many wildlife species depend on soft mast as an important food source (e.g. wild turkey, black bear, etc.). While such species may not depend solely on soft mast production, a significant portion of their diet is dependent on this food source to be in proximity to other habitat requirements.

Figure 65. Soft mast survey index, by season, on the Nantahala and Pisgah NFs, 1993-2012 (NCWRC 2012).



Summer soft mast production exhibits a decreasing trend across the Nantahala and Pisgah NFs, while fall soft mast production has been stable but with high annual variability (Figure 65).

Generally-speaking, bird populations within mesic oak forests on the Nantahala and Pisgah National Forests are stable to slightly increasing, except for species associated with early successional and young forest conditions and intact canopy conditions, where almost all species are declining, some significantly (Figure 65).

As discussed earlier, mesic oak forests provide essential habitat for many animal species. Of note is the fact that the NC Wildlife Action Plan identifies a relatively large suite of amphibians, mostly salamanders, as priority species associated with mesic oak forests (NCWRC 2005) (Table 29).

Table 29. Amphibian species identified as priority species in the NCWAP associated with mesic oak forests.

Scientific Name	Common Name
Ambystoma maculatum	spotted salamander
Ambystoma opacum	marbled salamander
Aneides aeneus	green salamander
Desmognathus aeneus	seepage salamander
Hemidactylium scutatum	four-toed salamander
Plethodon aureoles	Tellico salamander
Plethodon Chattahoochee	Chattahoochee slimy salamander
Plethodon glutinosus sensustricto	northern slimy salamander
Plethodon longicris	crevice salamander
Plethodon richmondi	southern ravine salamander
Plethodon ventralis	southern zigzag salamander
Plethodon wehrlei	Wehrle’s salamander
Pseudacris brachyphona	mountain chorus frog

Of these thirteen amphibian species, five have been identified as potential Species of Conservation Concern (highlighted in Table 29) during this plan revision process, largely because or rarity.

Effects of habitat change on plethodontid salamanders and green salamanders are well documented, but are less-documented on other amphibians. While no long-term monitoring data exists for most amphibians, NCWRC inventories have recently expanded the known range of many amphibian species, including salamanders.

Also of note is that mesic oak forests support a relatively large suite of bats threatened by white-nose syndrome (Table 30, reference potential Species of Conservation Concern section of the assessment). While no long-term monitoring data exists for most bat species, NCWRC and USFWS inventories have recently expanded the known range of most bat species.

Table 30. Bat species documented from the Nantahala and Pisgah NFs that are associated with mesic oak forests. Species susceptible to white-nose syndrome are highlighted.

Scientific Name	Common Name	Federally -listed	Generally Rare
Corynorhinus rafinesquii	Rafinesque's big-eared bat		Yes
C.townsendii virgineanus	Virginia big-eared bat	Yes	
Eptesicus fuscus	big brown bat		
Lasionycteris notivagans	silver-haired bat		
Lasiurus borealis	eastern red bat		
Lasiurus cinereus	hoary bat		
Lasiurus seminolus	Seminole bat		
Myotis grisescens	gray bat	Yes	
Myotis leibii	eastern small-footed bat		Yes
Myotis lucifugus	little brown bat		
Myotis septentrionalis	northern myotis		
Myotis sodalist	Indiana bat	Yes	
Perimyotis subflavus	tri-colored bat		

Game Species Harvest Trends

White-tailed deer

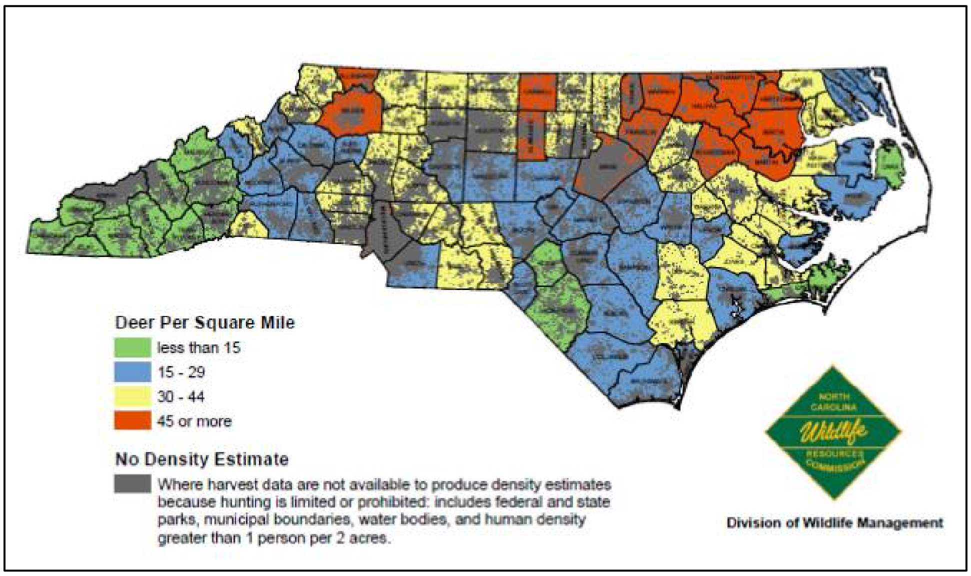
No wild animal in North Carolina is as recognizable as the white-tailed deer **(***Odocoileus virginianus*). Whether a mature buck with splendid antlers, a graceful doe, or a spotted fawn, the white-tailed deer is popular among hunters and wildlife enthusiasts.

White-tailed deer occupy many types of habitats in mountains and lowlands, including various forests and woodlands, forest edges, shrublands, grasslands with shrubs, and residential areas. They are often associated with early successional vegetation, especially near agricultural lands.

The white-tailed deer is an herbivorous animal. It will eat many green-leaved succulent plants and the tender new growths of stems and fruits. One of their most important food sources is acorns. White-tailed deer also forage on a variety of agricultural crops. Deer are so adaptable that they are found in almost any type of habitat. They like creek and river bottoms, oak ridges, pine forests, farmlands or any other type of habitat that offers food, water and cover.

Generally-speaking, white-tailed deer density is lower in western North Carolina than in other parts of the state (Figure 66).

Figure 66. Estimated white-tailed deer density in North Carolina in 2010 (NCWRC 2013).



White-tailed deer harvest has declined steadily in western North Carolina since 1991 (Figure 67). This may indicate that the forests are not providing optimal habitat for white-tailed deer. Additionally, actual white-tailed deer harvest from the Nantahala and Pisgah NFs is rapidly departing from expected harvest based on percent Forest ownership within the 18-county planning area (Figure 68). This may also indicate that the Forests are not providing optimal habitat for white-tailed deer.

Figure 67. White-tailed deer harvest from the Nantahala and Pisgah NFs, 1991-2012 (NCWRC 2013).

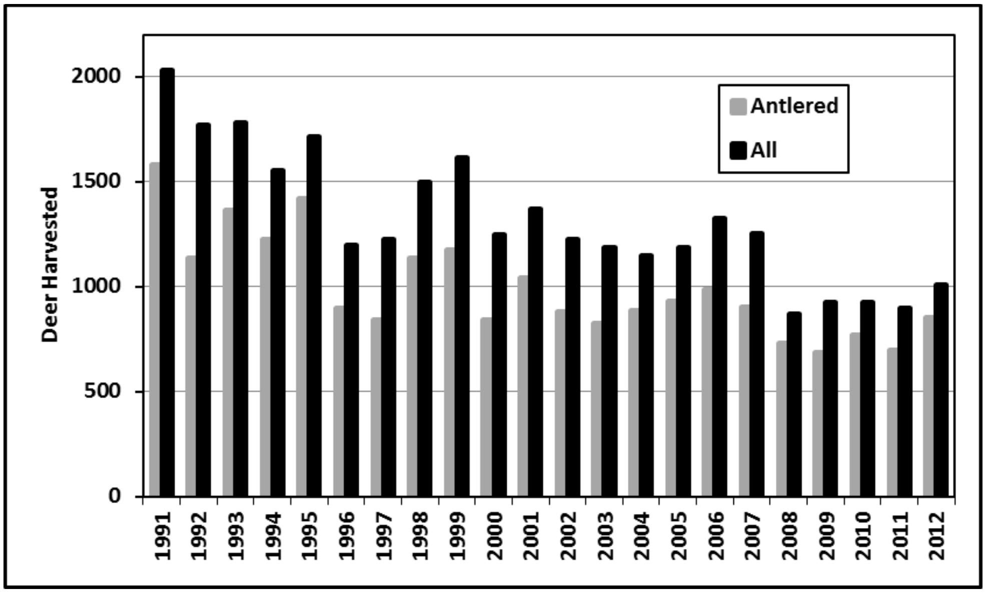
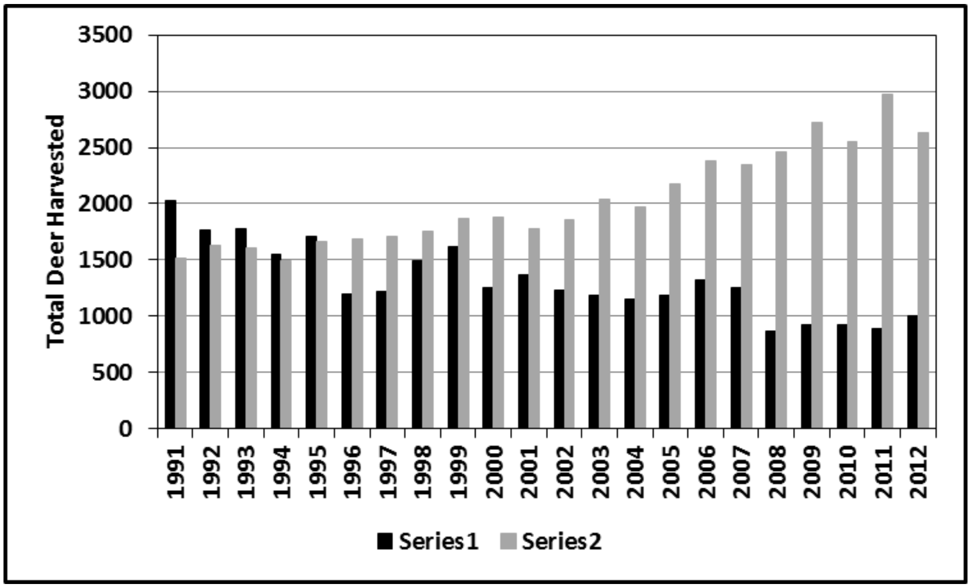

Deer Harvested
2000
1500
1000
500
0
Antlered
All
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012

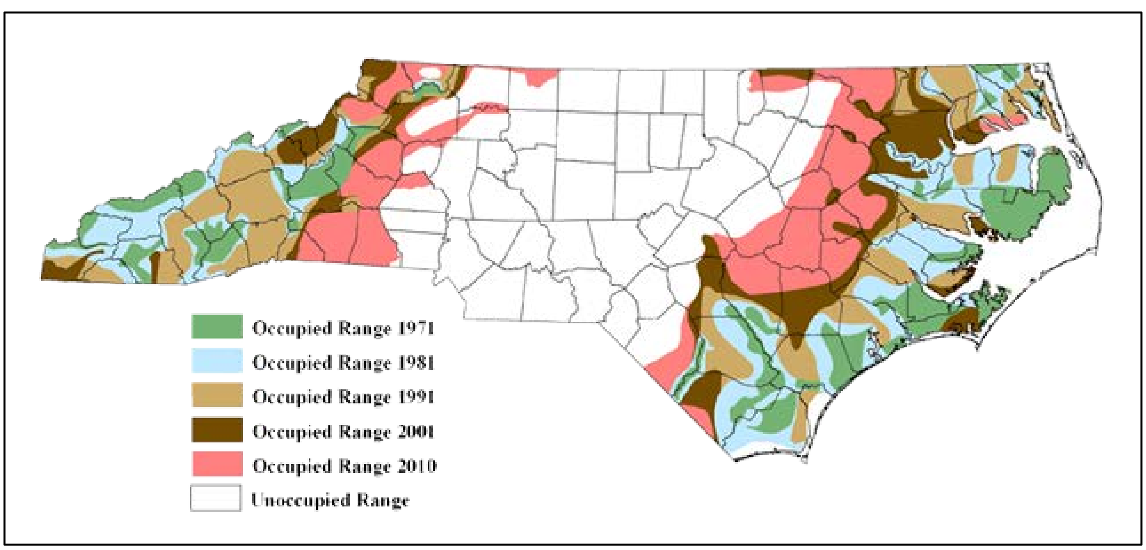
Figure 68. Actual white-tailed deer harvest from the Nantahala and Pisgah NFs (Series 1) versus expected harvest (Series 2), based on percent ownership within the 18-county planning area, 2008-2012 (NCWRC 2013).



Black bear

The black bear (*Ursus americanus*) is the only bear species found in North Carolina or anywhere in the eastern United States. Black bears were once restricted to remote areas and reached very low population levels in the mid-1900s. Today, black bears are found approximately 60% of the total land area of North Carolina (Figure 69).

Figure 69. Black bear range in North Carolina, 1971-2010 (NCWRC 2013). Each decade is additive to the previous decade.



Black bears inhabit forests and nearby openings, including forested wetlands. When inactive, they occupy dens under fallen trees, ground-level or above-ground tree cavities or hollow logs, underground cave-like sites, or the ground surface in dense cover. Black bears prefer mixed deciduous-coniferous forests with a thick understory but may occur in various situations. In the southeast, black bears benefit from the maintenance and enhancement of pocosins, mature gum, oak, and disturbed habitats (Hellgren et al. 1991). Bears prefer large expanses of uninhabited woodland or swampland with dense cover. These types of habitat provide the necessary travel corridors, escape cover and natural foods that bears need to thrive in North Carolina.

Black bear diet typically consists of acorns, berries, carrion, corn, fish, frogs, fruits, grasses, grubs, honey, insects, larvae, leaves, nuts, peanuts, reptiles, roots, seeds, small mammals, soybeans and wheat.

Black bear harvest has increased steadily in western North Carolina since 1991 (Figure 70). Harvest has occurred disproportionately on the Nantahala and Pisgah NFs versus other lands (Figure 71).

Figure 70. Black bear harvest from western North Carolina, 1991-2013 (NCWRC 2013).

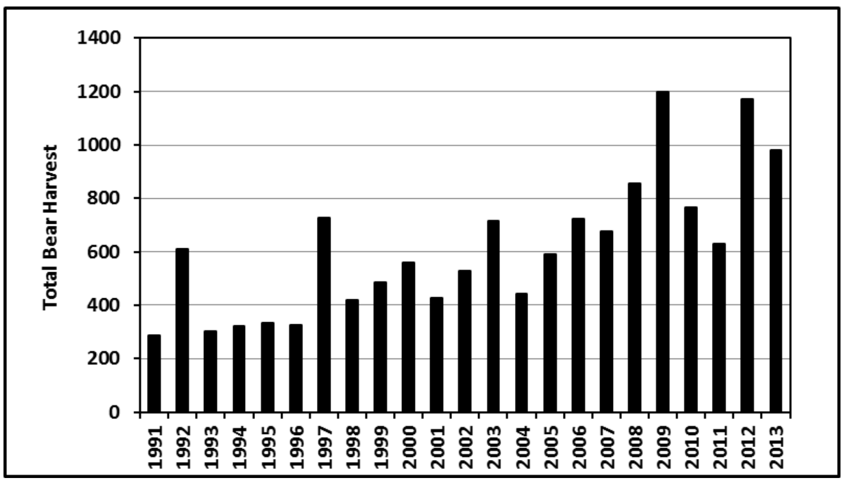
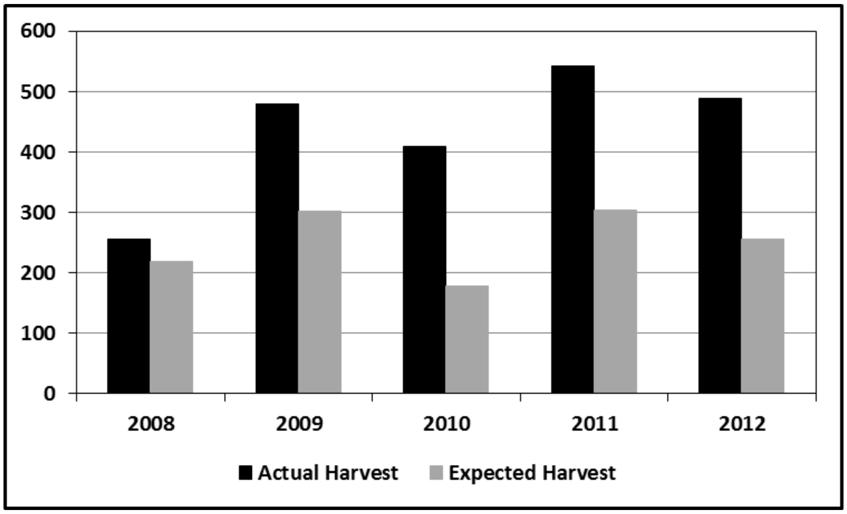


Figure 71. Actual black bear harvest from the Nantahala and Pisgah NFs versus expected harvest, based on percent ownership within the 18-county planning area, 2008-2012 (NCWRC 2013).

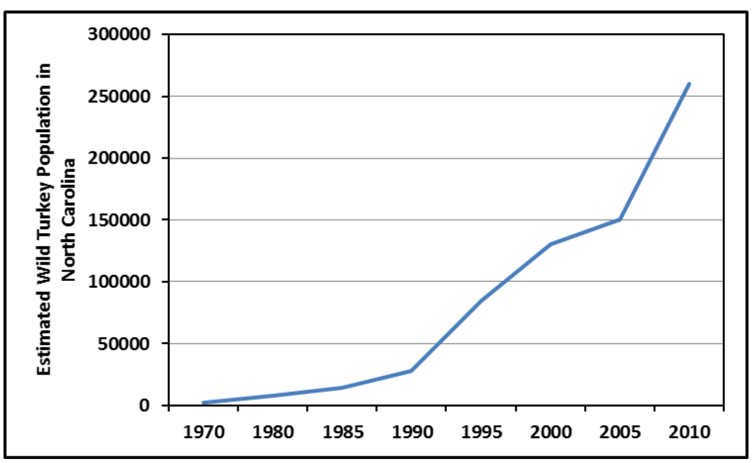


Wild turkey

When early European settlers arrived in America, wild turkeys (*Meleagris gallopavo*) were plentiful in North Carolina. However, by the turn of the century, few turkeys remained, due largely to unregulated hunting, rapid deforestation, and habitat destruction throughout the state. These low population numbers persisted into the 1960s.

Following this rapid and severe decline, the North Carolina Wildlife Resources Commission began what turned out to be an incredibly successful restoration program that involved live-trapping and relocating wild turkeys from sites in North Carolina and other states to areas in the state where the bird had previously disappeared. While official restoration efforts ended in 1990, the wild turkey now exists in all 100 North Carolina counties, and populations continue to grow (Figure 72).

Figure 72. Estimated wild turkey populations in North Carolina, 1970-2010 (NCWRC 2013).



The eastern wild turkey thrives best in areas with a mix of forested and open land habitats. Forested areas are used for cover, foraging, and for roosting in trees at night. Open land areas are used for foraging, mating, and brood rearing. Forest and open woodland, scrub oak, deciduous or mixed deciduous-coniferous areas are preferred, especially in mountainous areas (AOU 1998). Agricultural and other open areas provide important food resources, especially in winter.

Wild turkey harvest on the Nantahala and Pisgah NFs has increased steadily since 1991 (Figure 73). Although increasing, this harvest has been consistently lower than expected based on percent ownership across the 18-county planning area (Figure 74), which may indicate less than optimal habitat for wild turkey on the national forest lands.

Figure 73. Wild turkey harvest from western North Carolina, 1991-2013 (NCWRC 2013).

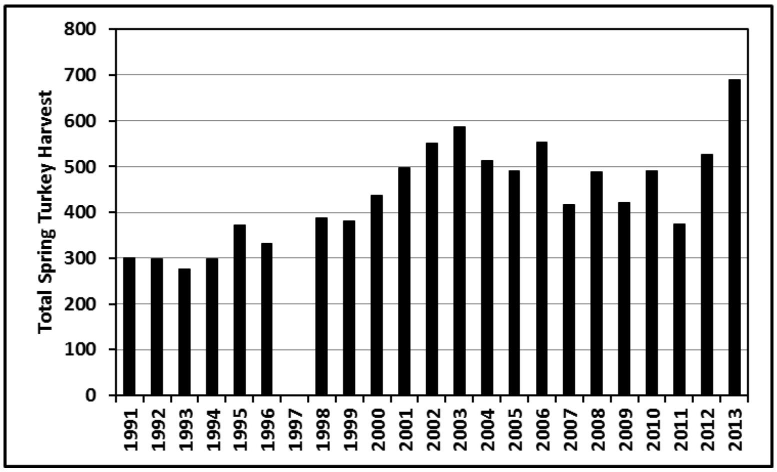
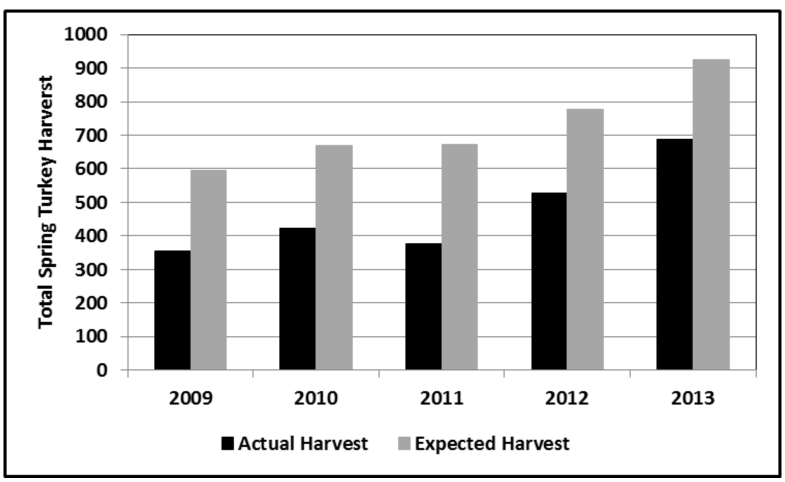


Figure 74. Actual wild turkey harvest from the Nantahala and Pisgah NFs versus expected harvest, based on percent ownership within the 18-county planning area, 2009-2013 (NCWRC 2013).



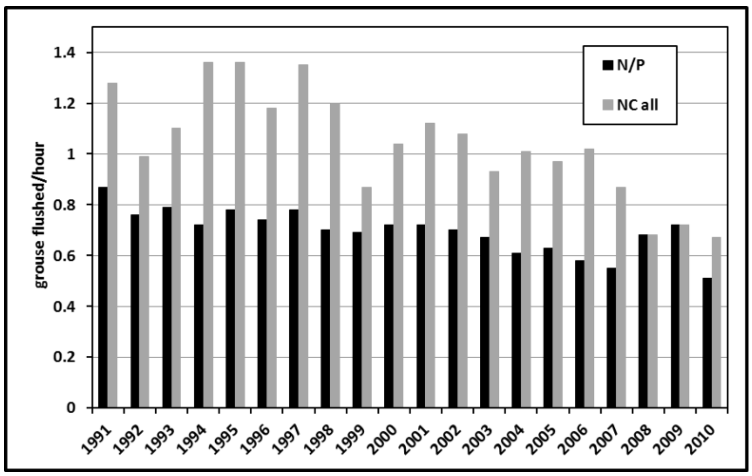
Ruffed grouse

Ruffed grouse (*Bonasa umbellus*) occupy dense forest with some deciduous trees, in both wet and relatively dry areas from boreal forest (especially early seral stages) and northern hardwood ecotone to eastern deciduous forest and oak-savanna woodland (AOU 1998). Young forest provides optimum conditions. Ruffed grouse nest in forests or woodlands with some deciduous trees, usually at base of tree, bush or stump. Drumming areas and broods are usually associated with a high density of woody stems and abundant ground cover.

Young grouse eat mainly insects and spiders. During summer, insects may comprise about 30% of adult grouse diet. Adults also eat many herbaceous plants, seeds, fruits, nuts, flowers, buds, and leaves of trees and shrubs. Staminate buds and catkins, especially willow, birch, alder, and hazelnut buds and catkins, are important food resources in winter and spring.

The flush rate of ruffed grouse on the Nantahala and Pisgah NFs has decreased steadily since 1991 (Figure 75). This same trend is evident across the range of the species in western North Carolina. Since grouse hunting often results in no harvest, hourly flush rates are used as indicators of occupied habitat and rough population density. This may indicate that the area, including the natinal forests, are lacking optimal habitat for ruffed grouse.

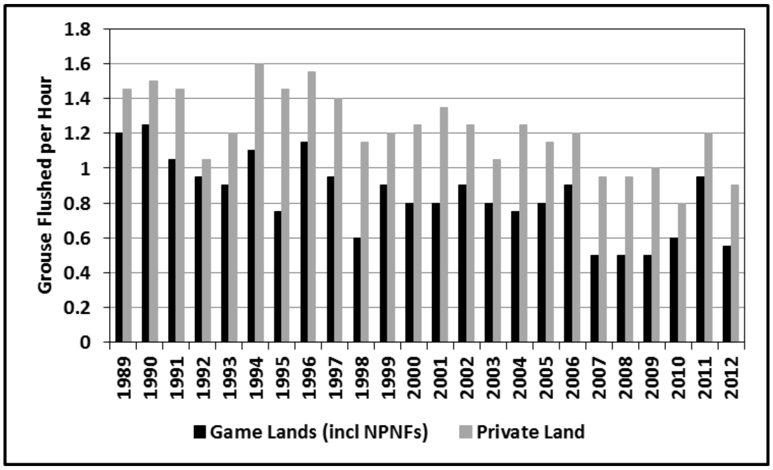
Figure 75. Ruffed grouse flush rates from western North Carolina, 1991-2013 (NCWRC 2013).



Additionally, since 1989, the NCWRC has conducted an annual avid grouse hunter survey to further estimate long term grouse hunting trends. Flush rates are presented both by hunting trip and by hour hunted in this report. Flush rates by hour may provide a more precise index of grouse abundance, and are used in this assessment. However it is recognized that hunters will change their hunting locations over time to areas with more grouse. This selective hunting behavior by avid hunters has a tendency to skew trend estimates and may not represent actual annual abundances or changes in abundance across the full landscape.

Since the inception of the survey, long term reported grouse flush rates have declined on both public and private land, although they continue to be higher on private land than on public land (Figure 76).

Figure 76. Ruffed grouse flush rates from western North Carolina avid grouse hunters, 1989-2012 (NCWRC 2013b). (NCWRC 2013b).



Acidic Cove and Rich Cove Ecological Zones

Cove forests are subdivided into acidic coves and rich coves. One distinguishing factor is the abundance of rhododendron in the understory of acidic coves, generally absent in rich coves.

Environmental Setting: Both the rich cove and acidic cove ecozones occur on protected slopes, sheltered steep gorges or ravines, and in gentle sloping valleys (Schafale and Weakley 1990; Pittillo et al. 1998). Moist soil conditions are frequently prevalent given the occurrence on north-facing slopes, the occurrence on protected concave slopes associated with streams, or the occurrence within the high rainfall belt along the Blue Ridge Escarpment. Soil nutrients are often limiting on acidic cove sites and they also generally have soils of low pH (McLeod 1988; Newell and Peet 1995). Rich cove sites are often rocky, the boulderfield subtype being one example (Schafale 2012). Excluding the boulderfield subtype, soils on rich cove sites tend to be deep, dark, and fertile, with varying degrees of bases which are greater in the montane and foothills rich subtypes (Natureserve 2013). High rainfall and high winds are the most important natural disturbance events influencing the cove ecozones.

Geographic Distribution

Acidic Cove

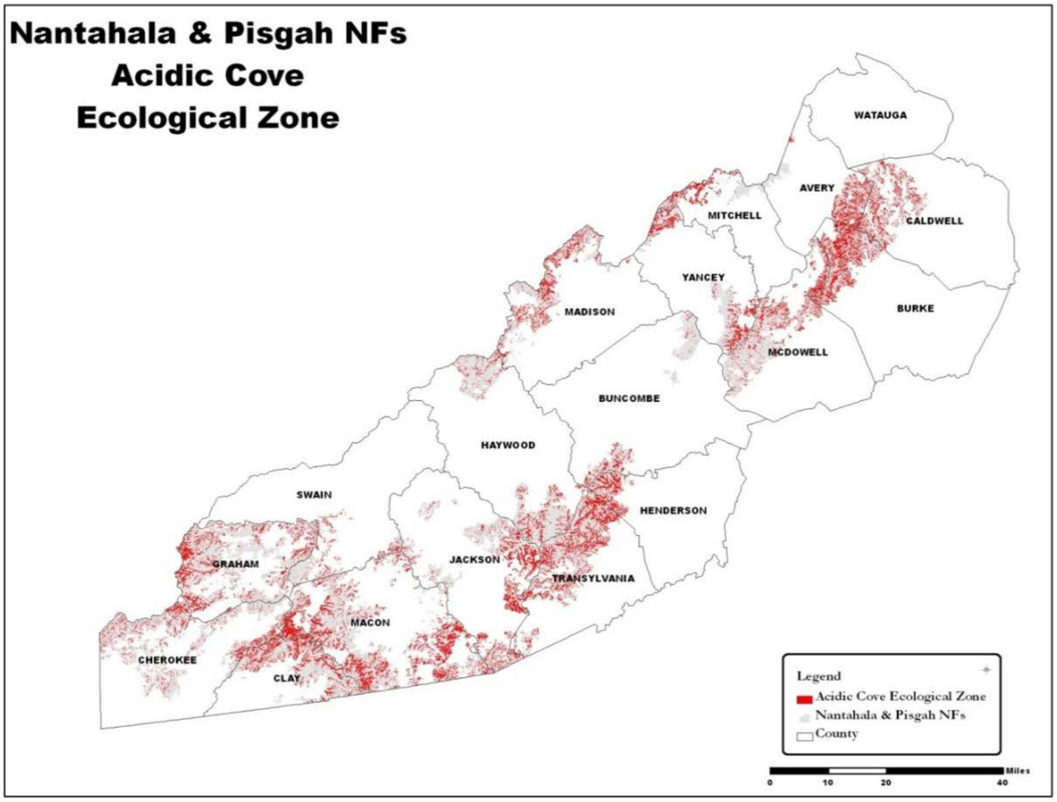
The acidic cove ecozone extends across the southern Appalachians from southern Kentucky and West Virginia to northern Georgia and South Carolina (Natureserve 2013). The acidic cove ecozone covers approximately 241,000 acres or 23% of the Nantahala and Pisgah NFs (Figure 77). On other lands in the surrounding 18-county area, the ecozone covers over a million acres or 21% of the area.

The silverbell acidic cove subtype is a rare subtype (globally ranked as G2) currently only known to be in eastern Tennessee and far western North Carolina in the Great Smoky Mountain National Park and Joyce Kilmer Wilderness. Other acidic cove subtypes are less rare, although updated analysis for the two eastern hemlock subtypes may lower the rank considering the recent mortality of eastern hemlocks from the nonnative invasive species, hemlock woolly adelgid.

In North Carolina, the acidic cove ecozone is most abundant at mid elevations, from 2,500-4,000 feet, however it can occur at the lowest elevations within the region to around 4,500 feet (Simon 2011; Natureserve 2013).

The most abundant acidic cove subtype within the Nantahala and Pisgah NFs is the typic acidic cove. The next most abundant subtype is the typic eastern hemlock forest but considering the current impacts from the hemlock woolly adelgid and massive hemlock death during the last three years, this community may eventually not be distinguishable from the typic acidic cove subtype (Schafale 2012). The eastern hemlock/white pine subtype is more abundant in gorges, particularly on the Blue Ridge Escarpment. These areas may eventually become dominated by white pines as eastern hemlocks are lost to the hemlock woolly adelgid. The chestnut oak/rhododendron subtype is evenly dispersed across the Nantahala and Pisgah NFs, and about as abundant as the typic eastern hemlock subtype. As previously mentioned, the silverbell subtype is restricted to Joyce Kilmer Wilderness within the Nantahala and Pisgah NFs, and these sites have also been heavily impacted by eastern hemlock mortality.

Figure 77. Distribution of acidic cove ecological zone across the Nantahala and Pisgah NFs.



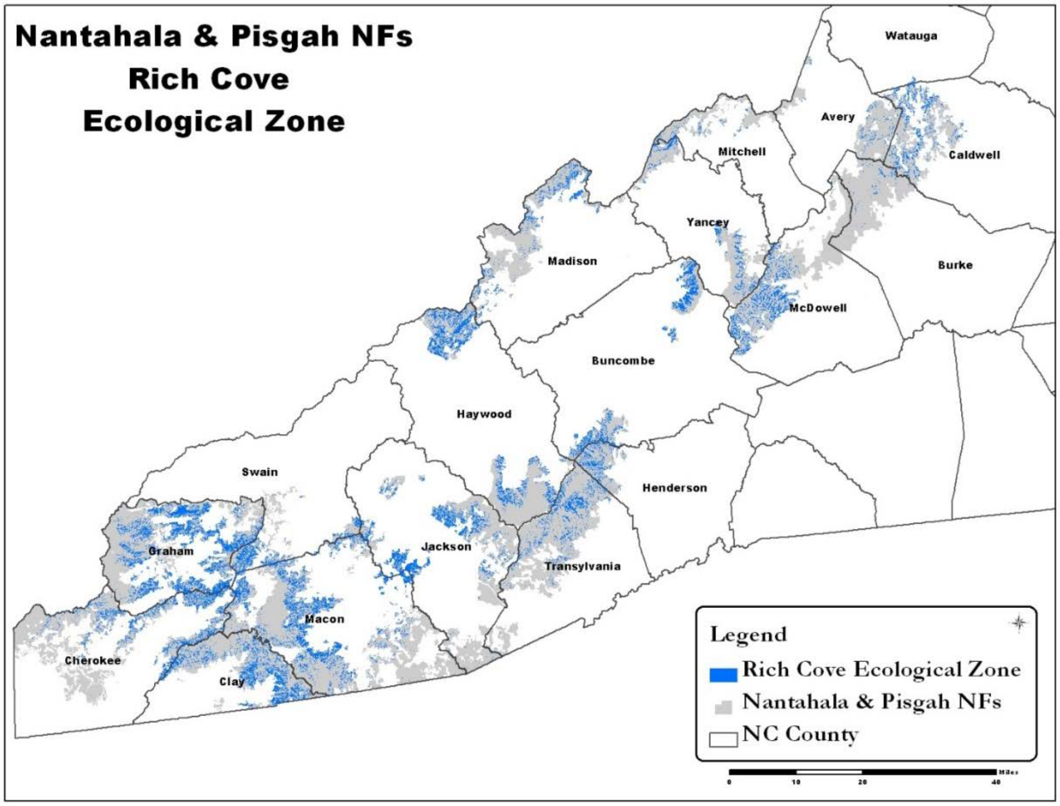
<u>Rich Cove</u>

This ecozone occurs across the southern Appalachians and foothills, from southern Virginia to northern Alabama, Georgia, and South Carolina (Natureserve 2013). The foothills rich subtype is the rarest of the six subtypes, with a global rank G2G3. Also restricted in range are the boulderfield and red oak subtypes which are globally ranked as G3.

The ecozone covers over 189,000 acres, or 18% of the Nantahala and Pisgah NFs (Figure 78). On other lands in the surrounding 18-county area, the ecozone covers slightly less than 16% of the area, approximately 766,000 acres.

The most abundant rich cove subtype on the Nantahala and Pisgah NFs is the montane intermediate rich cove. It is distributed across both forests with a greater extent across the Nantahala NF. Less is known about the abundance of the three other montane subtypes, although the rich intermediate is more evenly dispersed than the boulderfield and red oak subtypes. The rich intermediate subtype is disproportionate across the two forests with more occurrences on the Appalachian and Nantahala Ranger Districts, and slightly less on the Cheoah Ranger District. Both foothills subtypes are limited across the Nantahala and Pisgah NFs.

Figure 78. Distribution of the rich cove ecological zone across the Nantahala and Pisgah NFs.

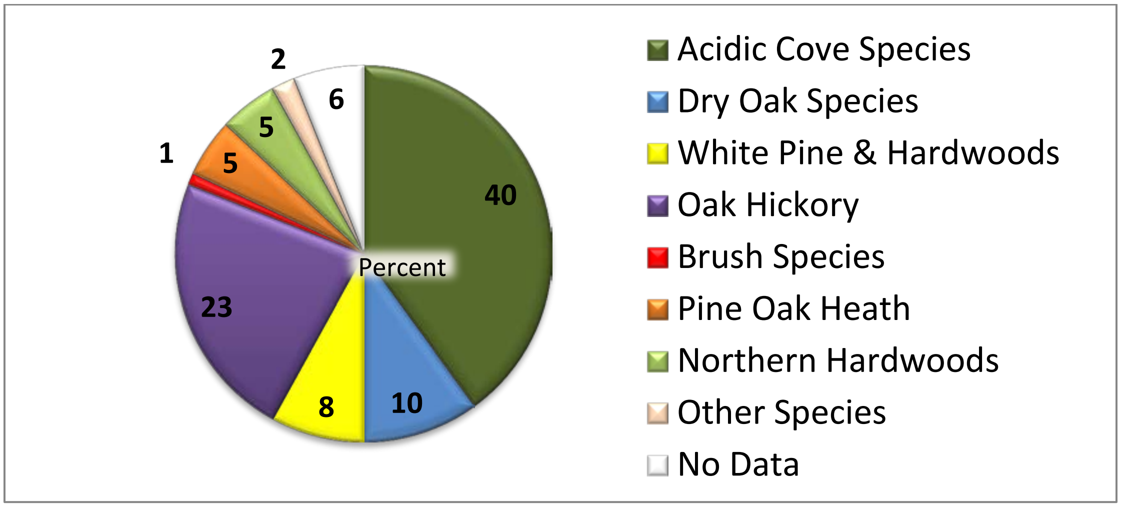


FSVeg Types

Acidic Cove

Within Nantahala and Pisgah NFs, FSVeg identifies 90,742 acres as having overstory components of the acidic cove community. These acres represent approximately 40% of the modeled ecozone (Figure 79). Fifty-one percent were identified as, communities typically expected to be adjacent to or in close proximity to the acidic cove community on the landscape (Figure 79) (Landfire 2009). Another more unique combination includes the presence of dry pine and oak community components (15%). Six percent of the modeled ecozone has missing forest type data.

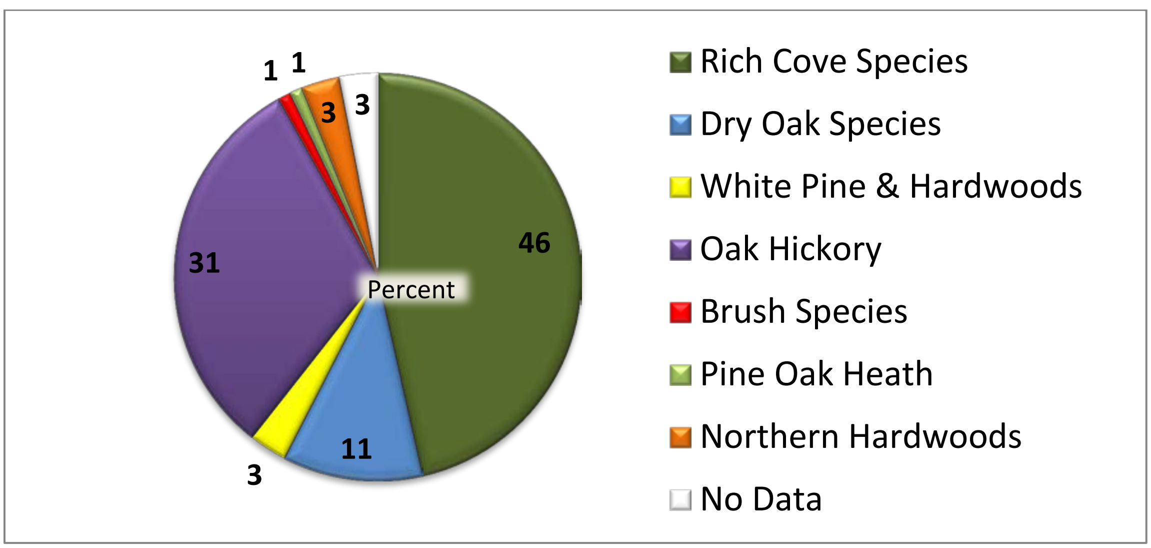
Figure 79. Nantahala and Pisgah NFs FSVeg forest type breakdown within the acidic cove ecozone.



<u>Rich Cove</u>

Within Nantahala and Pisgah NFs, FSVeg identifies 83,155 acres as having components of the rich cove community. These acres represent approximately 46 % of the modeled ecozone (Figure 80). Of the other acreage within the ecozone, the oak/hickory community makes up the largest percentage (31%). The ecozone also contains 11% dry oak communities (Figure 80) (Landfire 2009). There are also miscellaneous forest types in small acreages representing 1-3% of the ecozone. Three percent of the forest type data for the ecozone is unaccounted for, classified as “no data”.

Figure 80. Nantahala and Pisgah NFs FSVeg forest type breakdown within the rich cove ecozone.



Composition

Acidic Cove

Yellow poplar (*Liriodendron tulipifera*), black birch (*Betula lenta*), and eastern hemlock (*Tsuga canadensis*) dominate the more protected portion of typic acidic cove forests' overstory (Schafale and Weakley 1990). Codominant tree species include Fraser's magnolia (*Magnolia fraseri*), yellow buckeye (*Aesculus flava*), and red oak. Typic eastern hemlock subtype is dominated by eastern hemlock, although with the impact of hemlock woolly adelgid, the overstory may resemble typic acidic cove with a lower tree canopy density. White pine-eastern hemlock subtype is dominated by eastern hemlock and white pine. The silverbell subtype is dominated by silverbell (*Halesia tetraptera*) and eastern hemlock (Natureserve 2013).

Red oak and chestnut oak dominate on steeper north-facing slopes and comprise the chestnut oak/rhododendron subtype. Midstory shrub species include witch hazel (*Hamamelis virginiana*), sweet pepperbush (*Clethra acuminata*) and great laurel (*Rhododendron maximum*). *Rhododendron maximum* is by far the most common plant in the midstory, sometimes consisting of a 10-15 foot tall thicket. Some sites may have a more open shrub density.

Few herbaceous species are present within the acidic cove ecozone due to the dense midstory shrub component, and ocurrences tend to be widely scattered. Arrow-leaved ginger (*Hexastylis arifolia var. arifolia*), striped wintergreen (*Chimaphila maculata*), *Polystichum acrostichoides*, Indian cucumber root (*Medeola virginiana*), Indian plantain (*Goodyera pubescens*), Galax (*Galax urceolata*), and bellwort (*Uvularia puberula*) are the most frequently encountered herbs within this ecozone.

Bryophyte diversity (mosses and liverworts), particularly near streams and in steep gorges, is very high within this ecological zone. Vascular species richness varies greatly across the subtypes within this zone from a low of seven species in dense rhododendron-dominated areas to greater than 100 species in areas with more open understories (Ulrey 1999; Carolina Vegetation Survey 2013). Those areas dominated by eastern hemlock have the lowest species diversity of the five subtypes.

Rich Cove

Hardwood tree diversity is the highest within this ecological zone. Common species include tulip poplar, yellow buckeye, basswood (*Tilia americana*), white ash (*Fraxinus americana*), cucumber tree (*Magnolia acuminata*), silverbell (*Halesia tetraptera*), black cherry (*Prunus serotina*), and black birch. Sugar maple, black maple (*Acer nigrum*), and yellow wood (*Cladrastis kentuckea*) can be prevalent within the montane rich subtype (Schafale 2012). A diversity of deciduous shrubs occur in the open understory, including wild hydrangea (*Hydrangea arborescens*), sweet shrub (*Calycanthus floridus*), spicebush (*Lindera benzoin*), and strawberry bush (*Euonymus americanus*). Leatherwood (*Dirca palustris*) and mock–orange (*Philadelphus hirsutus*), may be present in the montane rich subtype while wild gooseberry (*Ribes cynosabati*) is often present within the boulderfield subtype (Schafale 2013).

Herbaceous diversity is typically higher within the rich cove ecozone compared to other ecozones across western NC. Spring ephemeral herbs are abundant including a diversity of violets (*Viola* sp.), *Trillium* species, numerous sedges (*Carex* sp.), many ferns such as maidenhair (*Adiantum pedatum*), and other diagnostic species such as spring beauty (*Claytonia virginica*), star chickweed (*Stellaria pubera*), yellow mandarin (*Prosartes lanuginosa*), bloodroot (*Sanguinaria canadensis*), black cohosh (*Actaea racemosa*), deciduous ginger (*Asarum canadense*), miterwort (*Mitella diphylla*) and foamflower (*Tiarella cordifolia*). This ecozone provides for the greatest densities of American ginseng (*Panax quinquefolius*) across the Nantahala and Pisgah NFs. On some rich cove sites, vascular species diversity can be as high as 135 species (Ulrey 1999; Carolina Vegetation Survey 2013). Epiphytic moss and liverwort diversity is high within this ecozone, particularly on middle age to older trees. In older forests, moss and liverwort covered downed woody debris is abundant.

Connectedness

<u>Acidic Cove</u>
Acidic cove forest generally occurs in patches associated with streams and adjacent slopes across the Nantahala and Pisgah NFs and western NC. The ecozone is mostly continuous and fairly evenly distributed across this area. The oak/rhododendron subtype occurs upslope of the typic acidic cove subtype forest, particularly on steep highly protected north-facing slopes. In less acidic substrates the zone grades to either rich cove forest or northern hardwood forest depending on the elevation. Mesic oak is also frequent upslope of this habitat across both low to mid elevations. Rare habitats either embedded within or adjacent to this zone include montane acidic cliff, spray cliffs, seeps, Southern Appalachian bogs, or swamp forest bog complexes. For plant species that are unique to acidic coves, the relatively even distribution of this ecozone should not affect the distribution or the potential genetic interchange of separate populations.

Due to significant impacts from hemlock woolly adelgids, high quality eastern hemlock subtypes are unevenly distributed and very patchy across the landscape. Except for possibly one moss, Anderson's melon-moss (*Brachymenium andersonii*), there are no facultative species restricted to the two eastern hemlock dominated subtypes (Amoroso 1997). In concentrated occurrences across this zone, generally for the typic acidic cove subtype, patch sizes can cover as much as 200 acres. This patch size is large compared to maximum patch sizes of other ecological zones across the Nantahala and Pisgah NFs.

<u>Rich Cove</u>
Rich cove forests generally occur as patches surrounding streams and adjacent slopes across the Nantahala and Pisgah NFs and western NC. The habitat is mostly continuous and fairly evenly distributed across this area. It often is upslope of acidic cove forest and downslope of mesic oak forest. At its upper elevation reach it typically grades into northern hardwood cove forest. In poorer quality low elevation sites, it is often found downslope of shortleaf pine forest.

Rare habitats, either embedded within or adjacent to this zone, include montane acidic or basic cliffs and seeps. Most plant species are not obligate in the rich cove ecological zone. A few rare species are restricted to this zone. One sedge species, *Carex careyana*, is only known in North Carolina within this habitat at a single site on the Nantahala NF. It represents an exception to other species with a broader distribution both in NC and across more ecological zones. For those facultative rich cove-associated species, the relatively even distribution of this zone should not affect the distribution or the potential genetic interchange of separate populations. In concentrated occurrences across this zone, generally for the typic rich cove subtype, patch sizes can occasionally cover as much as 100 acres. More typical patch sizes range from 10-20 acres.

Designated Areas

A little more than 25% of the acidic cove ecozone occurs within existing designated areas. The portion within the designated areas is dispersed across the two forests, although more concentrated on the Grandfather and Pisgah Ranger Districts.

A little more than 18% of the rich cove ecozone occurs within existing designated areas. The portion within the designated areas is relatively evenly dispersed across the mid-elevation range across the two forests; it is sparse in Caldwell, Cherokee, Macon, and Jackson Counties.

Cove Ecozones Vegetation Structure

As with the other ecozones in the Nantahala and Pisgah NFs, the rich and acidic coves have a widely distributed even-aged structure with stand ages typically between 70 and 100 years old (Van Lear et al. 2002). Many of the second growth forests are in a transition between the understory reinitiation and old growth phases (Oliver 1980) and may be so for the next 100 to 300 years (Guyon et al. 2003). As a result, Appalachian cove forests will probably experience a significant structural and compositional change over the next century (Baker and Van Lear 1998; Rivers et al. 1999).

The structures of acidic cove and rich cove forests in the Nantahala and Pisgah NFs are typically similar to one another. One of the greatest distinguishing factors between the acidic cove and rich cove ecozones is the presence of rhododendron in the understory and midstory of acidic coves. More than half (53%) of the acidic cove ecozone has shrub cover greater than 50%. Conversely, only about 37% of rich cove forests on national forest lands and non-national forest lands have high shrub cover (>50% cover). Within acidic coves exclusively on national forest lands, 61% have midstory densities greater than 50% (Table 31).

Table 31. LiDAR-derived shrub density classes for the rich and acidic cove ecozones and the percentage of ownership within each class (0 to 15 feet tall).

Shrub Cover	0 to 25%	26 to 50%	50 to 75%	76 to 100%
---------------------------------------Rich Cove-------------------------------------				
Nantahala & Pisgah	26%	34%	26%	14%
Non- National Forest	33%	35%	23%	10%
---------------------------------------Acidic Cove------------------------------------				
Nantahala & Pisgah	12%	26%	33%	28%
Non- National Forest	25%	31%	27%	17%

The presence of rhododendron in the understory and midstory may be explained by both soil conditions and land use history (Van Lear et al. 2002). Modern day densities and coverage of rhododendron within cove forests may have developed after the exploitive logging and chestnut blight, giving it the opportunity to expand under the era of fire exclusion (Baker and Van Lear 1998; Vandermast and Van Lear 2002; Van Lear et al. 2002). Historical accounts place rhododendron in more localized patches along riparian corridors or present in low densities under the intense fire regime employed by Native Americans and early European settlers (Nesbitt 1941; Guyon et al. 2003). Fire exclusion has allowed rhododendron to expand out onto slopes and to ridge tops on north facing coves (Baker and Van Lear 1998; Rivers et al. 1999; Van Lear et al. 2002). Research found that rhododendron became more dominant on sites 15 to 20 years after twentieth century logging (Vandermast and Van Lear 2002). Areas of sparse rhododendron on side slopes were younger than those closer to streams, indicating a movement away from the streamside zone over the last 70 years (Baker and Van Lear 1998). This expansion may have resulted in an increase in acidic cove forests over time during the era of fire suppression (Vandermast and Van Lear 2002).

Acidic cove structural development is highly influenced by rhododendron. In stands that were harvested in the late 1800s to the early 1900s, with rhododendron densities suppressed by fires (or at least knocked back), a new cohort of overstory trees were able to establish and grow ahead of the rhododendron. In many cases, these trees now form the high forest canopy above a dense midstory and understory of rhododendron (Baker and Van Lear 1998). Where the rhododendron is dense in the midstory, it is capable of excluding most tree and herbaceous species from establishing (Rivers et al. 1999; Vandermast and Van Lear 2002; Van Lear et al. 2002). Both Baker and Van Lear (1998) and Van Lear et al. (2002) reported that other plant regeneration decreased remarkably as rhododendron density increased.

At low and moderate densities, the most shade-tolerant herbaceous and tree species are able to germinate and establish though few of the tree species are able to advance into the sapling stage (Baker and Van Lear 1998; Rivers et al. 1999). Hemlock, the most likely to succeed, is now lost to hemlock woolly adelgid (HWA) (Van Lear et al. 2002; Guyon et al. 2003). Historically an abundant and dominant component of acidic cove forests, eastern hemlock has been severely impacted by HWA across the Nantahala and Pisgah NFs. In many cases, mature hemlock have been reduced to standing dead stems, drastically altering the overstory structure and adding large quantities of snags to the ecozone. In the presence of dense rhododendron, these structural changes may be permanent as newly created canopy gaps are overwhelmed by rhododendron where it could become the climax species (Baker and Van Lear 1998; Vandermast and Van Lear 2002; Van Lear et al. 2002).

In the absence of rhododendron, modern second-growth cove forests have similar structures in the overstory, with a high forest canopy of dominant tree species. More than 60% of rich coves have canopy heights greater than 75 feet. Acidic coves are similar on national forest lands (56%), with a lower amount on non-national forest lands (Table 32). In a comparison between old growth and second growth rich cove forests Guyon et al. (2003) reported canopy heights averaging 143 feet for old growth sites and 129 feet for second growth sites.

Table 32. LiDAR-derived canopy height classes for the rich cove and acidic cove ecozones and the percentage of ownership within each class.

Height Class (feet)	1 to 10	11 to 20	21 to 30	31 to 50	51 to 75	76 to 100	100 plus
Rich Cove							
Nantahala & Pisgah	2%	2%	2%	9%	24%	41%	22%
Non-National Forest	8%	2%	2%	9%	25%	38%	25%
Acidic Cove							
Nantahala & Pisgah	2%	2%	3%	12%	34%	36%	12%
Non-National Forest	12%	4%	4%	12%	33%	28%	6%

Many second growth cove forest overstories are dominated (in basal area) by tulip poplar (Clebsch and Busing 1989; Vandermast and Van Lear 2002; Guyon et al. 2003). Clebsch and Busing (1989) and Runkle (1998) noted that larger natural disturbances (tornadoes) and other manmade disturbances (agriculture, overstory harvest) have resulted in cove forests dominated by tulip poplar. Baker and Van Lear (1998) and Van Lear et al. (2002) found overstories of post-chestnut blight, logged stands dominated by tulip poplar, red maple, eastern hemlock, and birch. Composite FIA data also typifies the dominance of cove sites by mesic hardwood species (Figure 81). Others have also noted an oak component in second growth cove stands (Guyon et al. 2003). Post-chestnut blight, non-logged overstories were dominated by oak species, eastern hemlock and birch (Van Lear et al. 2002). There is an oak component within the composite FIA data, which shows that in some cases it is capable of reaching large size classes (Figure 81: B, C). When hemlock is found alive, it most often occurs in dense thickets of regeneration and small trees (Figure 81: C), in gaps within rhododendron, or in rich cove forests where it plays a more subordinate role to mesic hardwoods. Seedling and shrub densities were greater in the second growth sites (Guyon et al. 2003). Rhododendron was denser on logged sites than old growth sites (Van Lear et al. 2002).

Research in old growth remnant cove forests indicates that two to three species dominated the original overstories. These were usually shade-tolerant species like sugar maple, eastern hemlock, and silverbell (Runkle 1998; Guyon et al. 2003), however, tulip poplar has been found to dominate some old growth cove sites (Guyon et al. 2003). The differences in overstory species translate into differences in canopy architecture between old growth cove stands and second growth stands (Clebsch and Busing 1989). The species in old growth stands had wider spreading crowns and multiple overlapping levels of vegetation. Canopy species in second growth cove stands (eg. tulip poplar) were smaller canopied and non-overlapping. The age structure of old growth rich cove stands was found to be uneven-aged (Lorimer 1980). American chestnut was likely more important in coves, representing 6-40% of the pre-blight cove forests (Lorimer 1980; Vandermast and Van Lear 2002; Van Lear et al. 2002), and may have had a greater predominance in the cove ecozones than previously thought (Wang et al. 2013). With the loss of American chestnut, shade-intolerant species such as tulip poplar and birch were able to become established. Clebsch and Busing (1989) found that gaps as small as 0.03 acres provided enough light for tulip poplar to be abundant in old growth stands. It is not known at this time if second growth forests will develop conditions similar to those currently found in remnant old growth stands.

Overstory basal area was found to be similar between old growth and second growth sites (Table 33). Second growth sites had larger numbers of small overstory trees and unlogged coves had their basal area distributed between fewer lager trees. Age structure is mixed, with individual trees reaching greater than 300 years (Busing 2004). Large standing snags are also characteristic of old cove forests, comprising 59% of dead material in study sites (Busing 2004). With the loss of hemlock to HWA within acidic coves and to lesser degree rich coves, the presence of large standing snags within the cove ecozones is likely to remain high or dramatically increase.

Table 33. Comparison of structural characteristics between second growth and old growth cove forests.

Study	**Guyon et al. 2003**		**Clebsch and Busing 1989**	
Average stand	Second Growth	Old Growth	Second Growth	Old Growth
Density (#/acre)	410	146	1,054	349
Basal Area(ft2/acre)	169	178	195	210
	All trees > 2.5 inches dbh		All trees > 5 feet tall	

The understory development of second growth rich cove forests is much more robust, heavily diversified with species, and contains a correspondingly highly diversified structure compared to acidic coves. Here the herbaceous community adds a high degree of structural diversity to the understory. Many rich cove understories contain multiple layers of herbaceous plants and more of a gap between the midstory and the main canopy. In the case of tulip poplar dominated overstories, many shade-tolerant species develop (Guyon et al. 2003) when the stands reach the understory reinitiation phase (Oliver 1981).

Figure 81. Composite Forest Inventory Analysis Data representing abundance and dominance of tree species/groups for the acidic and rich cove ecozones in the stand initiation (A), stem exclusion (B), and understory reinitiation (C) phases.

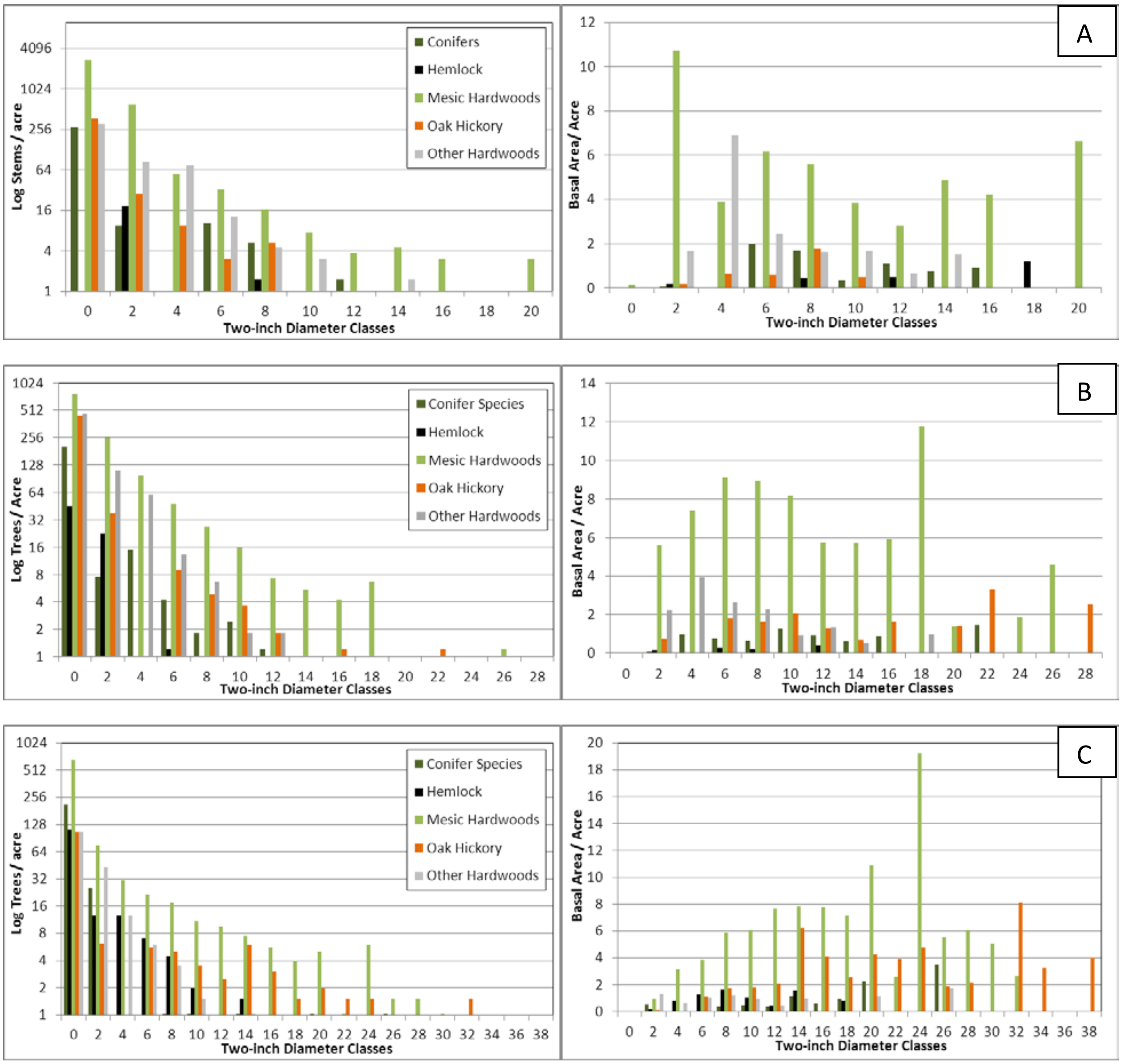


Figure 82. View of composite FIA data taken within rich and acidic cove ecozones during the stand initiation stage.

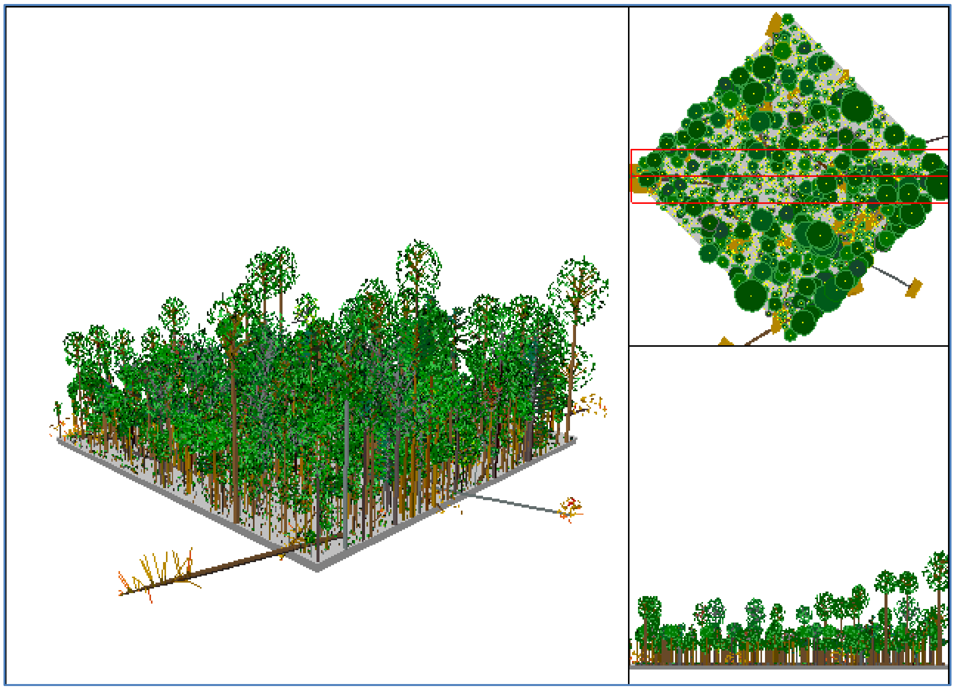


Figure 83. View of composite FIA data taken within rich and acidic cove ecozones during the stem exclusion stage.

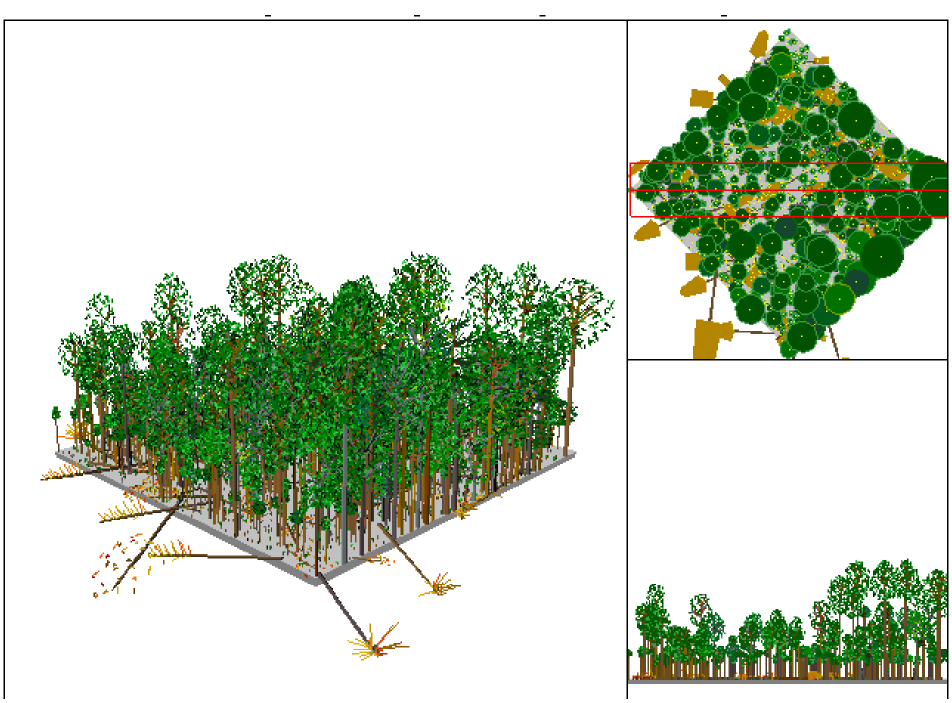
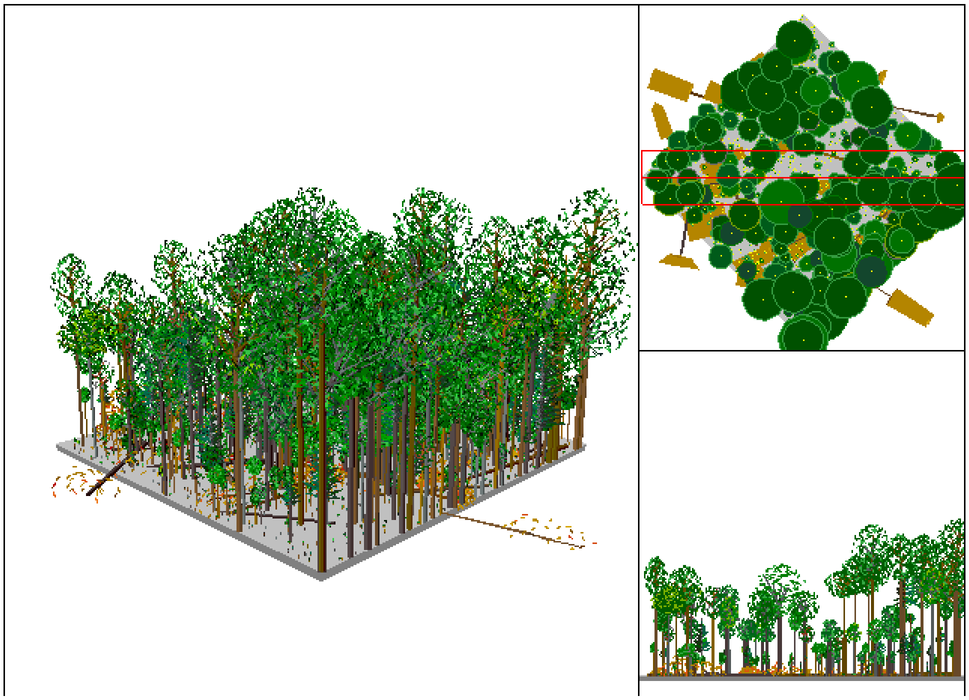


Figure 84. View of composite FIA data taken within rich and acidic cove ecozones during the understory reinitiation stage.



Age Class

<u>Current Silvicultural Age Class Distributions</u>

Both the rich and acidic cove ten year age class distributions display an age distribution similar to other ecozones on the Nantahala and Pisgah NFs, given their land history. The 70 to 100 year old age classes represent regrowth after the intensive harvesting era of the early part of the last century. Fifty-five percent and 57% of the rich cove and acidic cove ecozone, respectively, are represented in these age class (Tables 34, 35). A smaller uptick occurs in the 1980's. In the last ten years, close to 0-1% of the earliest age class (0-10 year forest) has been created in cove forests, close to 2,400 acres, according to FSVeg data (Tables 34, 35). Very little of either cove ecozone is represented by stands greater than 200 years.

Table 34. Nantahala and Pisgah NFs rich cove silvicultural age class distribution.

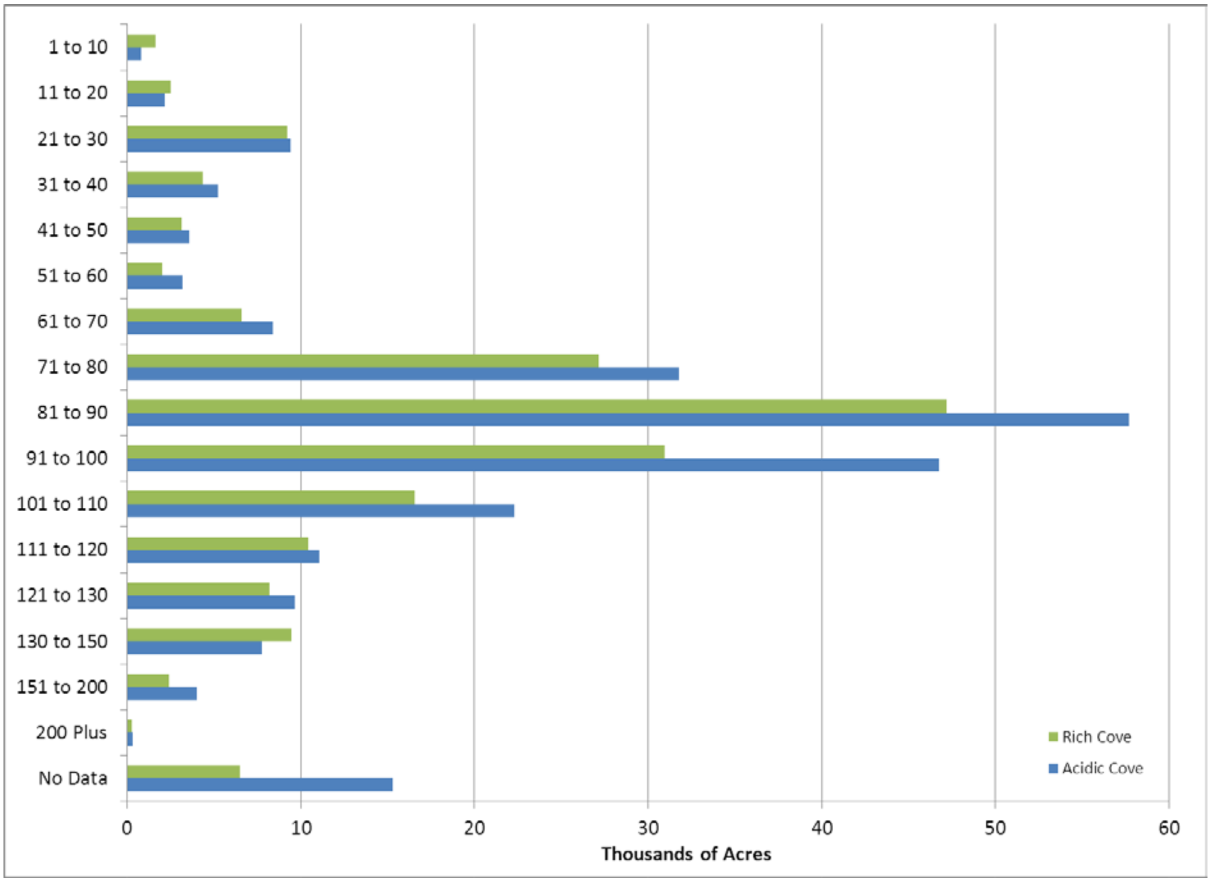
Silvicultural	Closed	Open	Total
Age Class	Acres (%)	Acres (%)	Acres (%)
1 to 10	1,597 (1)	16 (0)	1,613 (1)
11 to 20	2,481 (1)	7 (0)	2,487 (1)
21 to 30	9,216 (5)	1 (0)	9,217 (5)
31 to 40	4,345 (2)	24 (0)	4,369 (2)
41 to 50	2,679 (1)	255 (0)	3,107 (2)
51 to 60	1,928 (1)	102 (0)	2,030 (1)
61 to 70	6,256 (3)	307 (0)	6,563 (3)
71 to 80	25,063 (13)	2,006 (1)	27,172 (14)

81 to 90	40,889 (22)	6,175 (3)	47,166 (25)
91 to 100	25,089 (13)	5,842 (3)	30,939 (16)
101 to 110	11,988 (6)	4,561 (2)	16,549 (9)
111 to 120	6,280 (3)	4,105 (2)	10,415 (6)
121 to 130	4,582 (2)	3,589 (2)	8,172 (4)
131 to 150	5,519 (3)	3,933 (2)	9,452 (5)
151 to 200	1,825 (1)	585 (0)	2,410 (1)
200 Plus	166 (0)	95 (0)	261 (0)
No Data	6,465 (3)		
Total	188,386 (100)		

Table 35. Nantahala and Pisgah NFs Acidic Cove silvicultural age class distribution.

Silvicultural	**Closed**	**Open**	**Total**
Age Class	Acres (%)	Acres (%)	Acres (%)
1 to 10	772 (0)	20 (0)	792 (0)
11 to 20	2,169 (1)	7 (0)	2,177 (1)
21 to 30	9,138 (4)	236 (0)	9,421 (4)
31 to 40	5,103 (2)	118 (0)	5,222 (2)
41 to 50	3,019 (1)	358 (0)	3,564 (1)
51 to 60	2,963 (1)	214 (0)	3,178 (1)
61 to 70	7,373 (3)	989 (0)	8,362 (3)
71 to 80	28,900 (12)	2,827 (1)	31,794 (13)
81 to 90	46,632 (19)	10,996 (5)	57,708 (24)
91 to 100	36,076 (15)	10,619 (4)	46,745 (20)
101 to 110	15,215 (6)	7,076 (3)	22,295 (9)
111 to 120	6,616 (3)	4,456 (2)	11,074 (5)
121 to 130	4,955 (2)	4,690 (2)	9,645 (4)
131 to 150	4,552 (2)	3,214 (1)	7,767 (3)
151 to 200	2,340 (1)	1,671 (1)	4,021 (2)
200 Plus	144 (0)	187 (0)	331 (0)
No Data	15,311 (6)		
Total	239,407 (100)		

Figure 85. Nantahala and Pisgah NFs acidic cove and rich cove silvicultural age class distribution.

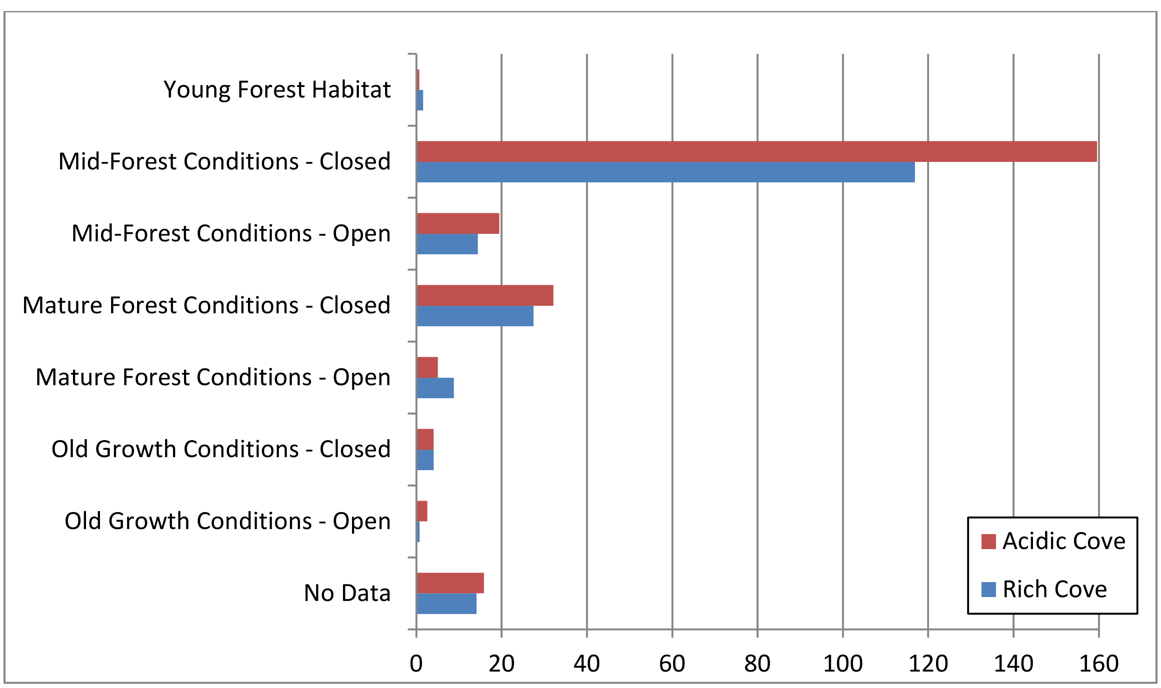


<u>Structural Age Class Distributions</u>
The majority of both the rich and acidic cove ecozones are currently in closed mid-forest conditions. Though not present in the Landfire model, there is a portion of the mid-forest conditions that have open forest conditions. This condition may be the result of, or be increased in the future by loss of eastern hemlock, especially in the acidic cove ecozone. The closed condition is also abundant in the mature forest class, though this overall class and the old growth class represent a small portion of the ecozones.

Table 36. Nantahala and Pisgah NFs rich cove and acidic cove ecozone current BpS age structure class conditions.

Age/Structure Class	Age Range	Rich Cove Acres (%)	Acidic Cove Acres (%)
Young Forest Habitat	1 to 9	1,567 (1)	729 (0)
Mid-Forest Conditions – Closed	10 to 99	116,863 (62)	159,580 (67)
Mid-Forest Conditions – Open	10 to 99	14,434 (8)	5,063 (2)
Mature Forest Conditions - Closed	100 to 140	27,439 (15)	32,147 (13)
Mature Forest Conditions - Open	100 to 140	8,780 (5)	19,415 (8)
Old Growth Conditions - Closed	141 Plus	4,049 (2)	4,078 (2)
Old Growth Conditions – Open	141 Plus	736 (0)	2,557 (1)
No Data	---	14,131 (8)	15,837 (7)
Totals	All	188,386 (100)	239,407 (100)

Figure 86. Nantahala and Pisgah NFs rich cove and acidic cove ecozone current BpS age structure class conditions.



Disturbance Dynamics

Acidic Cove

Gap-phase dynamics, driven by wind and ice storms, allow for tree regeneration within this ecozone, and tree fall gaps have been shown to allow regeneration of intolerant species, particularly in older forests (Lorimer 1980; Runkle 1982). Patch sizes can vary from single trees to more numerous trees, depending on the level and frequency of disturbance. Larger tree gaps may form considering recent impacts to eastern hemlock.

LiDAR analysis of canopy cover has been completed over the majority of the Nantahala and Pisgah NFs, only excluding the Grandfather Ranger District since the collected data resolution is less robust. Existing canopy coverage up to 40%, which would provide young forest characteristics in various gap sizes, occurs across about 3% of the Nantahala and Pisgah NFs in the acidic cove ecological zone. This contrasts with 19% of the landscape with up to 40% canopy coverage across non-national forest lands in the surrounding 18-county area. About 91% of this ecozone on the national forest has a closed canopy (> 60% cover) while the private lands have slightly less than 70%.

Historically, this zone was subject to very infrequent fires with surface fires at an average frequency of about 88 years (Wade et. al. 2000; Landfire 2009). Typically this zone, particularly where shrub density is high, is moist enough to extinguish any fires originating from the uplands. Mixed severity fires are rare, occurring at greater than a 500-year return frequency and typically following a large scale insect defoliation or drought event (Landfire 2009). With an emphasis on larger landscape burns in the Nantahala and Pisgah NFs, 8,622 acres of the acidic cove ecozone have been burned over the last seven years (a little more than 3% of the ecozone). In general, these areas served as fire breaks for the upland burns.

Compared to other ecozones, fewer non-native invasive plant species have been identified within acidic cove forest, undoubtedly due to the typically dense evergreen shrub layer. However, vegetation manipulated sites within this ecozone do have aggressive non-native plant species. These more open mesic sites often have Japanese stiltgrass (*Microstegium vimineum*), Japanese honeysuckle (*Lonicera japonica*), Chinese yam (*Dioscorea polystachya*), privet (*Ligustrum* sps), and oriental bittersweet (*Celastrus orbiculatus*). Japanese knotweed is often associated with riverbanks in undisturbed sites in this ecozone.

Rich Cove

Gap-phase dynamics, driven by wind and ice storms, allow for tree regeneration within the rich cove ecozone, and tree fall gaps have been shown to regenerate intolerant species, particularly in older forests (Lorimer 1980; Runkle 1982). Patch sizes can vary from single trees to more numerous trees, depending on the level and frequency of disturbance.

LiDAR analysis of canopy cover has been completed over the majority of the Nantahala and Pisgah NFs, only excluding the Grandfather Ranger District since the collected data resolution is less robust. Existing canopy coverage up to 40%, which would provide young forest in various gap sizes, occurs across less than 3% of the Nantahala and Pisgah NFs in the rich cove ecozone. This contrasts with the 14% of the landscape that holds up to 40% canopy coverage across the other lands in the assessed area. About 90% of this zone has a closed canopy (> 60% cover) on the national forest while the other lands have slightly more than 72%.

Historically, this zone was subject to very infrequent fires with surface fires at an average frequency of about 88 years (Wade et. al. 2000; Landfire 2009). This zone is typically moist, particularly where shrub density is high, and fires with low flame heights are spotty through the community. Mixed severity fires are rare, occurring at greater than a 500-year return frequency and typically following a large scale insect defoliation and/or drought event (Landfire 2009). Emphasis on larger landscape burns during the last seven years across the Nantahala and Pisgah NFs has resulted in burns within the rich cove ecozone amounting to 4,190 acres, or a little more than 2% of the ecozone. In general, these areas served as fire breaks for the upland burns.

Except for the floodplain forest ecozone, the rich cove ecozone has the highest prevalence and risk for non-native invasive plant species on the Nantahala and Pisgah NFs. Except for possibly Chinese silvergrass (*Miscanthus sinensis*), seventeen of the most invasive non-native plant species of western NC have been located within this ecozone based on surveys during the last 10 years. Infestations of Japanese stilt grass (*Microstegium vimineum*), Oriental bittersweet (*Celastrus orbiculatus*), Chinese yam (*Dioscorea polystachya*), Japanese Spiraea (*Spiraea japonica*), privet (*Ligustrum* sps), and Japanese honeysuckle (*Lonicera japonica*) have their highest densities within this ecozone. Given the abundant moisture and the typically open understory, this habitat is particularly at risk for invasion. Openings from active management or a large scale disturbance can greatly increase the size of existing infestations as well as the risk of invasion from nearby infestations.

Cove Terrestrial Wildlife

Appalachian cove hardwood forests represent some of the most diverse ecosystems in the world outside of tropical zones (Hunter et al. 1999). High vegetative diversity, combined with topographic, microclimatic, and soil characteristics combine to provide an extremely productive habitat for numerous mammals, amphibians, and birds. High numbers of endemic salamanders are present (Petranka 1998), and population densities of these animals in cove forests make these extremely important habitats. Additionally, Appalachian cove forests support very high densities of breeding birds, especially mature forest-dependent neotropical migrants (Hunter et al. 1999).

Because these forests occur in cool, moist and sheltered sites, frequent large scale disturbances are uncommon. Tree fall gaps and wind throw are likely the most common forms of natural disturbance in older cove forests, producing uneven-aged stands that are structurally complex. Fire is not a likely source of disturbance in these forests.

In general, the most significant problem affecting cove forest habitat is conversion to other uses such as residential development (NCWRC 2005). Residential development in mountain coves often differs from development in other habitats of the region, in that homes and associated spaces are often interspersed within the forest. The result may be that direct habitat loss as a result of the houses and associated structures may be more limited than other types of development.

Reduction in habitat quality within cove forests can also be attributed to bisection by roads, driveways, and other gaps, and can have significant impact on wildlife populations (Rosenberg et al. 2003). Furthermore, several nonnative invasive pest species likely have an impact on the cove forest habitat (and wildlife populations), including the hemlock woolly adelgid, gypsy moth, and beech scale, as well as several non-native invasive plants. Finally, timber harvesting and conversion to other forest types (e.g. white pine) may decrease the quality and availability of this habitat in the future.

Stresses on individual wildlife species associated with cove hardwood forests include isolation or extremely limited ranges of populations (e.g. cerulean warbler, crevice salamander), which could lead to increasing chances of genetic depression or stochastic events having negative consequences for the sustainability of populations. Some bird species which require a diverse understory may be impacted by the aging of stands, which can result in decreased plant diversity until the stand reaches age classes sufficient to produce canopy gaps (Hunter et al. 2001).

Range-wide Trends

Two species with high conservation priority are associated with mid- to late-succession cove forests in the Southern Appalachians – Swainson’s and cerulean warblers (Hunter et al. 1999). Cove hardwoods also provide optimal habitat for other priority species including black-throated blue warbler, Acadian flycatcher, worm-eating warbler, hooded warbler, scarlet tanager, ovenbird, and blue-headed vireo (Hamel 1992).

The most inland and northerly populations of Swainson's warbler are in the Southern Appalachians. Most of these occur within lower elevation cove hardwood sites with dense understories, usually dominated by rhododendron along streams. However, some populations extend into mixed hemlock-hardwood dominated stands at their lower elevation limits.

Mature and virgin stands of mixed mesophytic hardwood forests within the Northern Cumberland Plateau and Ohio Hills support the highest densities of cerulean warblers in the Southeast, whereas the species occurs in much lower numbers in the southern Blue Ridge, even in some of the oldest cove hardwood stands in the ecoregion (Hunter et. al 1999). Recently, AMJV (2013) associated cerulean warblers with larger, “super-emergent” trees and complex forest structure and less with certain levels of canopy cover. Cerulean warblers are highly area-sensitive in at least some physiographic areas, requiring at least 4,000 ha (10,000 ac) of continuous forested habitat to support a sustainable population (Hamel 1992), but this may not be an important factor in the heavily forested landscape of the SBR. Instead forest conditions seem to be the most important factor associated with the species occurrence in the SBR.

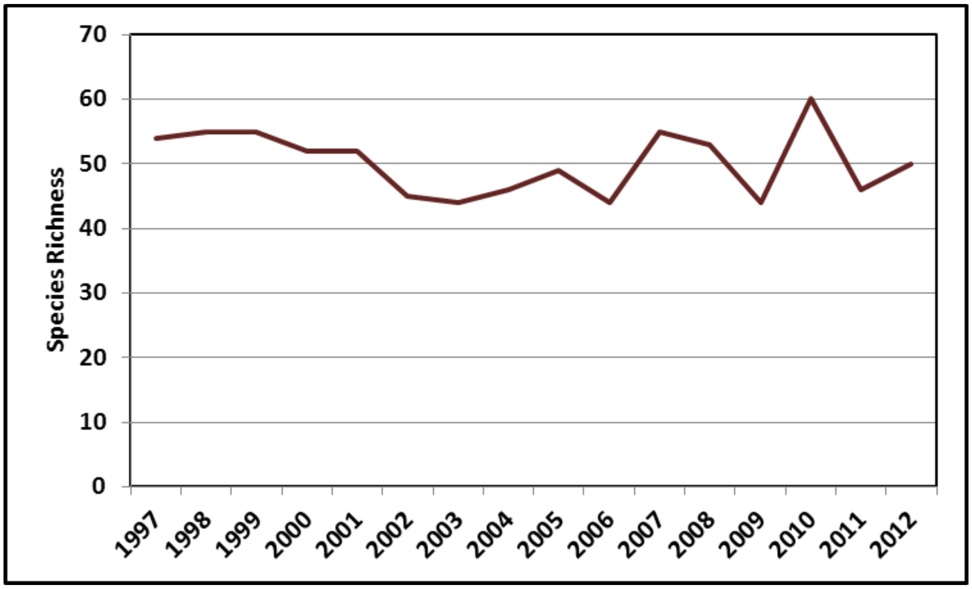
Like Swainson’s warbler, several species are associated with the shaded, well-developed shrub layer common in these forests. Black-throated blue warbler occurs in most forest types within the SBR but reach their highest densities in mature cove hardwood stands at middle and higher elevations (Kendeigh and Fawver 1981). Hooded warbler is typically found at low-to-mid elevations on moist hillsides and ravines that contain a dense understory (Robinson 1990; Hamel 1992). Similar habitat requirements have been identified for worm-eating warbler (Robinson 1990; Hamel 1992; Bartlett 1995). Ovenbirds spend most of their time on or near the ground, but unlike the other species mentioned, it seems that ovenbird, at least in the SBR, can be found in many different forest habitat types at various elevations. However, they tend to favor mature forests with more open shrub layers on drier sites (Kendeigh and Fawver 1981; Katz 1997). Some “rich” cove sites in the SBR with sparse shrub layers undoubtedly provide optimal habitat for ovenbirds.

Like cerulean warbler, several other priority species are associated with the diverse canopy layers of mature cove stands. Blue-headed vireo is associated with a variety of habitat types, but support highest density, abundance, and percent occurrence in late succession cove forests (Kendeigh and Fawver 1981; Katz 1997), especially those containing hemlock trees (Holmes and Robinson 1981; Katz 1997). Acadian flycatcher is often found in older stands with large-sized trees and a moderate to open understory along small streams at lower elevations (Hamel 1992; Bartlett 1995). Scarlet tanager has been recorded in a number of mature forest habitat types, but had high breeding densities in older cove forests in the GSMNP (Kendeigh and Fawver 1981).

Forest-Level Trends

Ninety-two bird species have been documented from cove forests in the Nantahala and Pisgah NFs between 1997 and 2012 (Appendix A, USFS 2013). Within this same monitoring period, species richness is stable to slightly declining, although high annual variability is evident (Figure 87).

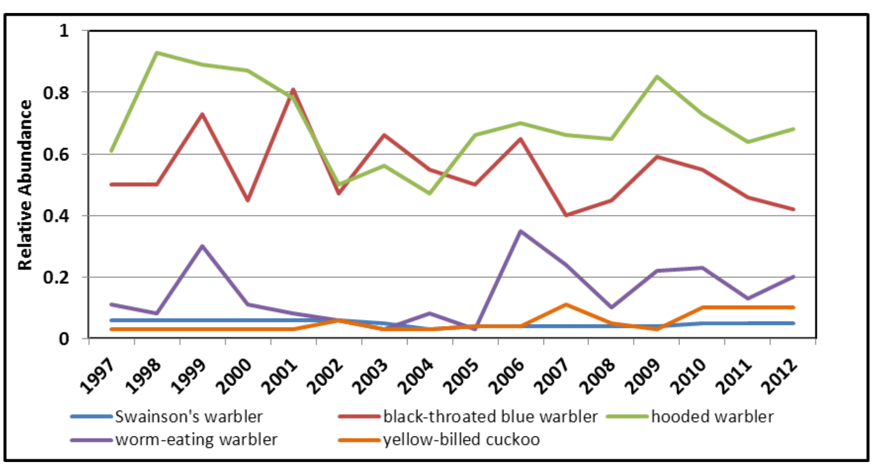
Figure 87. Landbird species richness within cove forests on the Nantahala and Pisgah NFs, 1997-2012 (R8Bird 2013).



Long-term monitoring data (USFS 2013) includes five priority bird species associated with well-developed understory of cove forests (Hunter et al. 1999; NCWRC 2005). These species include Swainson's warbler, black-throated blue warbler, hooded warbler, worm eating warbler, yellow-billed cuckoo.

Populations of Swainson's warbler, yellow-billed cuckoo, and worm-eating warbler, while at low densities, have been stable to very slightly increasing within cove forest habitats within the 16-year monitoring period (Figure 88). Similarly, while at higher densities and exhibiting greater annual variation, hooded and black-throated blue warbler populations have demonstrated a slightly decreasing trend within cove forests during the 16-year monitoring period (Figure 88).

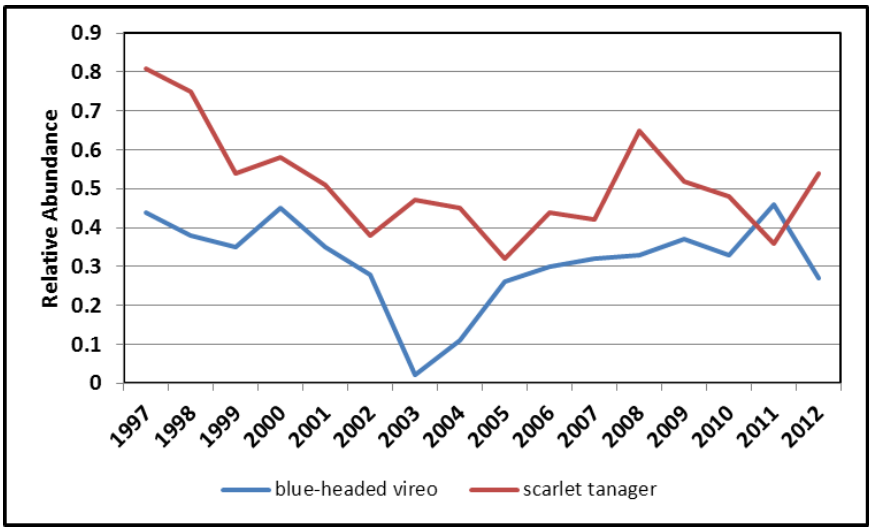
Figure 88. Relative abundance of bird species associated with well-developed understory within cove forests, 1997 through 2012 (USFS 2013).



Additionally, long-term monitoring data (USFS 2013) includes four NCWAP (NCWRC 2005) and PIF (Hunter et al. 1999) priority bird species associated with intact canopy conditions within cove forests. These species include cerulean warbler, blue-headed vireo, black-billed cuckoo, and scarlet tanager. Black-billed cuckoo are also associated with dense thickets and open woodlands within cove forests. The AMJV (2013) recognizes cerulean warblers may be associated with "super-emergent" canopy trees and that forest conditions for this species require attention. Cerulean warbler and black-billed cuckoo densities are so low within cove forest habitats on the Nantahala and Pisgah NFs that trends for these species cannot be accurately displayed.

Populations of blue-headed vireo and scarlet tanager have decreased within cove habitats during the during the 16-year monitoring period, with annual variability being high (Figure 89).

Figure 89. Relative abundance of bird species associated with intact canopy condition within cove forests, 1997 through 2012 (USFS 2013).



Generally-speaking, bird populations within cove forests are slightly decreasing. Wildlife habitat quality (and therefore populations) within this ecozone is susceptible to stresses such as population growth (i.e. urban development), wind throw, and climate change. These factors, along with less vegetation management and infrequent fire disturbance, affect structural composition and therefore habitat diversity, which is often reflected in bird population trends.

Additionally, cove forests provide essential habitat for a suite of terrestrial salamanders, many of which are rare or endemic (Table 37).

Table 37. Amphibian species identified as priority species in the NCWAP associated with northern hardwood forests.

Scientific Name	**Common Name**
Ambystoma maculatum	spotted salamander
Ambystoma opacum	marbled salamander
Aneides aeneus	green salamander
Desmognathis aeneus	seepage salamander
Desmognathus wright	pigmy salamander
Plethodon aureoles	Tellico salamander
Plethodon chattahoochee	Chattahoochee slimy salamander
Plethodon longicris	crevice salamander
Plethodon richmondi	southern ravine salamander
Plethodon ventralis	southern zigzag salamander

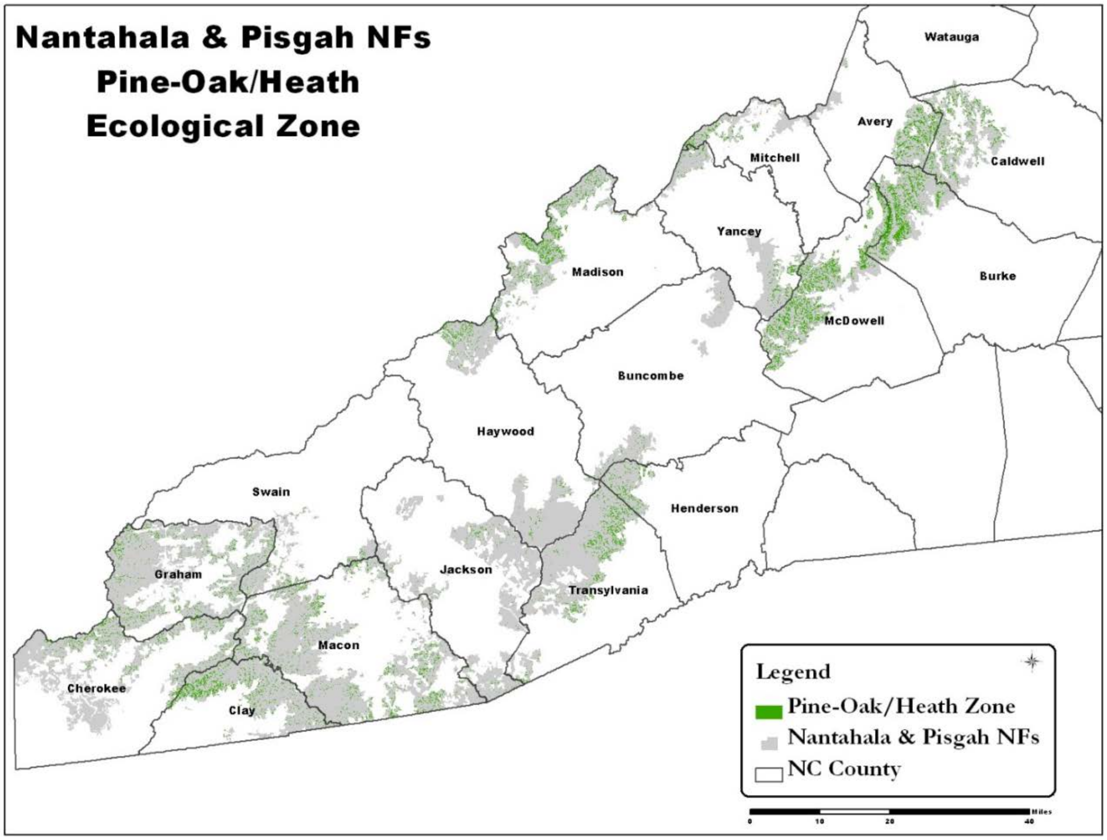
Effects of habitat change on plethodontid salamanders are well documented (Petranka 1988); however, such effects on other amphibians are less documented. While no long-term monitoring data exists for most amphibians, NCWRC inventories have recently expanded the known range of many amphibian species.

Pine-Oak/Heath Ecological Zone

Environmental Setting: This zone occurs on highly exposed ridgetops, and steep, spur slopes from low- to mid-elevations, 2000-4500 feet (Landfire 2009; Natureserve 2013). It is often on southerly and westerly exposures in acidic, thin, infertile soils (Newell and Peet 1995). Moisture content is very limiting as the soils are excessively-drained. Wind, ice storms, pine beetle infestations, and fire are all important natural disturbance events influencing this zone.

Geographic Distribution: Across the Nantahala and Pisgah NFs the zone covers about 101,000 acres, or about 9.8% of the area (Figure 90). It is unevenly distributed across both forests with much greater abundance within the Grandfather Ranger District and within Madison, Clay, and Transylvania Counties. Within other lands in the surrounding 18-county area the type's distribution type is less abundant, covering about 5.6% of the area. Three pine-oak subtypes have been identified within this ecozone: typic forest, high elevation, and low elevation mixed pine woodland. This community ranges from southwestern Virginia and southeastern Kentucky south through western North Carolina and eastern Tennessee into northeastern Georgia and northwestern South Carolina (Natureserve 2013). The typic forest subtype for this zone is more common across the Nantahala and Pisgah NFs as well as for those other lands within the surrounding 18-county area. This subtype is globally ranked G3G4. The low elevation mixed pine woodland subtype is less common in the planning area than the dry heath, but is abundant across its range, globally ranked as G4?, although in the absence of fire the global rank of this type may be downgraded significantly (Natureserve 2013). The high elevation pine subtype is the least common of the three, is only known from North Carolina and is ranked globally as G2 (Natureserve 2013).

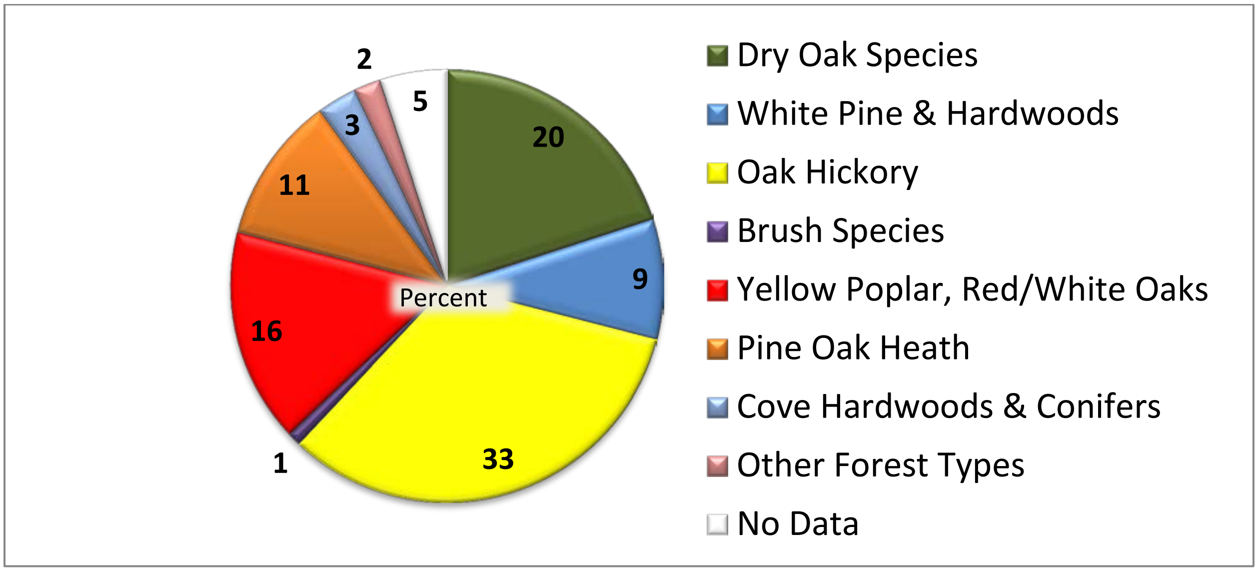
Figure 90. Distribution of Pine-Oak/Heath Ecological Zone across the Nantahala and Pisgah NFs.



FSVeg Types

Within Nantahala and Pisgah NFs, the vegetation management database identifies 10,330 acres as having components of the pine oak heath community, these acres representing approximately 11% of the ecozone (Figure 91). Of the other forest communities within the ecozone 82% may be identified as community components, communities typically expected to be adjacent to, or in close proximity to the pine oak heath community on the landscape (Figure 91) (Landfire 2009). Roughly 6% of the ecozone contains forest types that may represent a disturbed condition. There are also miscellaneous forest types in small acreages representing 2% of the ecozone.

Figure 91. Nantahala & Pisgah FSVeg forest type breakdown within the pine-oak/heath ecozone.



Composition

This ecozone is dominated by pitch pine (*Pinus rigida*), a combination of pitch pine and table mountain pine (*Pinus pungens*), or a mix with shortleaf pine (*Pinus echinata*) at low elevations. Varying amounts of chestnut oak, scarlet oak, black oak, white oak, red maple, blackgum, sourwood (*Oxydendrum arboreum*), and white pine (Schafale and Weakley 1990; Natureserve 2013). Ericaceous shrubs dominate this xeric community, particularly those sites without periodic wildfires. Mountain laurel is the dominant shrub with lesser amounts of flame azalea and bear huckleberry. Hillside blueberry is dominant with mountain laurel at low elevation sites. In the absence of fire the shrub thickets can be quite dense.

Herbaceous diversity can be quite sparse within the denser shrub thickets. For those more open examples yellow stargrass, trailing arbutus, spotted wintergreen, and Carolina lily are characteristic. In more open sites with recurrent burns the herbaceous layer is more diverse with a mix of grasses and herbs. Characteristic species include fragrant goldenrod (*Solidago odora*), turkey beard (*Xerophyllum asphodeloides*), grey goldenrod (*Solidago nemoralis*), stiff aster (*Ionactis linariifolius*), little bluestem (*Schizachyrium scoparium*), Indian grass (*Sorghastrum nutans*), grass-leaved golden-aster (*Pityopsis graminifolia*), Maryland golden-aster (*Chrysopsis mariana*), hairy lespedeza (*Lespedeza hirta*), black-eyed Susan (*Rudbeckia hirta*), goat's-rue (*Tephrosia virginiana*), partridge-pea (*Chamaecrista fasiculata*), Appalachian sunflower (*Helianthus atrorubens*), and *Baptisia tinctoria*. Species richness varies across the zone from low counts of 10 to higher counts of over 55 species (Ulrey 1999). The greatest diversity is present within those examples with recurrent fire and a more open structure.

Connectedness

The habitat is typically upslope of dry-mesic oak forest or dry oak forest and can grade to high elevation red oak forest in upper elevations. Rocky outcrop communities, including low and high elevation granitic domes, rocky summits, and glades can be adjacent to the type. Carolina hemlock bluffs can be embedded within the type. Patch sizes of this habitat are variable from a few acres on steep narrow ridges to more than 50 acres on dry west or south-facing slopes. This habitat is not limiting across the Nantahala and Pisgah NFs, however high quality fire-maintained habitat is quite patchy. It is uncertain the role of fire suppression and the current abundance of this zone. Without periodic fire, this community will gradually succeed into forests dominated by red maple, chestnut oak, or scarlet oak, resembling a dry oak zone forest (Landfire 2009). In the absence of fire, pines may be extirpated from the site leaving the forest to resemble dry oak forest. Fire-loving species that occur within this type can only occur in very small population sizes or be widely dispersed.

Designated Areas

A little less than 30% of pine-oak/heath ecozone is currently within existing designated areas. Those acres within the designated areas are present across both forests with the greatest amount on the Grandfather Ranger District.

Disturbance Dynamics

Periodic pine beetle outbreaks and wind events provide the greatest influence on the canopy creating small and large gaps. Recurrent wildfires maintain a partially open structure and influence the species composition. Deep, poorly decomposing duff layers plus dead wood from pine beetles outbreaks, and flammable shrubs contribute to a fire-prone plant community. Fire suppression during the last 50-70 years has perpetuated the even-aged structure and allowed for the dominance of more mesic midstory and canopy species, and increased hardwoods to the detriments of pines. Pre-settlement forests, fire history analysis, and recent dendrochronology studies indicate a fire return interval with the predominance of low intensity fires every 4-7 years, and occasional more intense fires would help to maintain and regenerate the fire-tolerant oaks (Frost 1998; Harrod et al 1998; Aldrich et al. 2010). Historical evidence of fires in the early twentieth century indicates that large fires were more common during below-average precipitation years (Harmon 1982). In the Great Smokies, effective pine regeneration was not present in mature pine stands until the canopy was reduced by 40% and the shrub layer by 80% (Jenkins et al. 2011). The pine-oak zone has more than 63% of its area occupied with greater than 50% shrub cover, likely a consequence of lack of recurrent burns. Current openings within this type are low, slightly more than 5% with less than 40% cover, and slightly less than 9% between 40-60% canopy cover. Single and repeated wildfires in Linville Gorge Wilderness increased species diversity and richness, particularly for grasses and forbs (Kelly et al 2012 presentation). Repeated burns effectively reduced overstory hardwood density as well as shrub density. The U.S. Forest Service conducted prescribed burns on a little more than 4% of this ecozone within the past seven years.

Nonnative Invasive Plant Species

The risk nonnative invasive plant species spreading in the pine-oak/heath ecozone is very similar to that in the dry oak forest zone. The greatest threat from invasive plants to this community has occurred in areas where a high-intensity, high-severity wildfire completely consumed the duff layer and removed the overstory canopy. Within these sites princess tree (*Paulownia tomentosa*), tree-of-heaven (*Ailanthus altissima*), butterfly bush (*Buddleja davidii*), Chinese silvergrass (*Miscanthus sinensis*), and spotted knapweed (*Centaurea biebersteinii*) have rapidly invaded if propagules were relatively near the wildfire (Kuppinger and White 2007). In sites with less severe wildfires within this zone, the spread of invasive non-native species has not occurred.

Pine-Oak/Heath Vegetation Structure

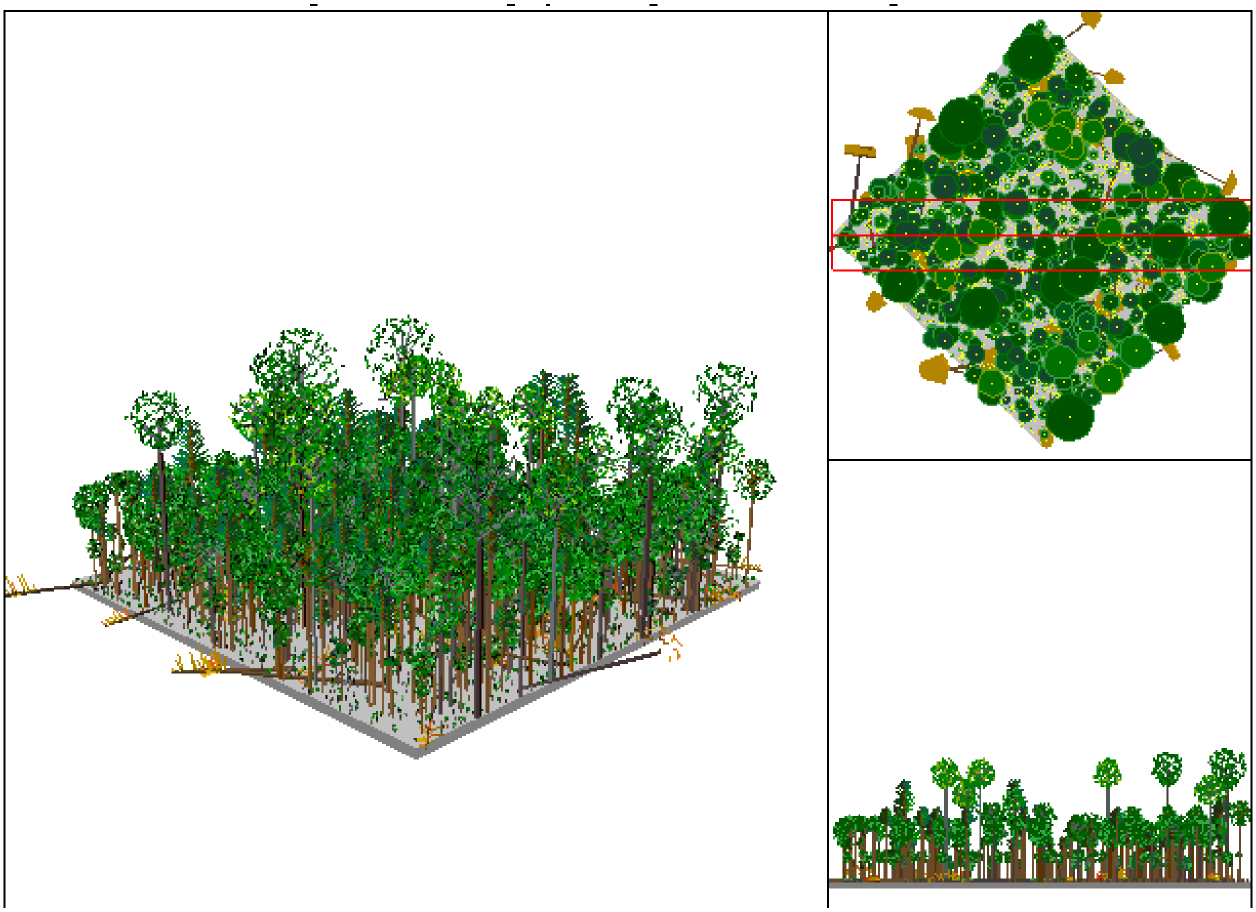
This unique ecosystem in the southern Appalachians is found at mid-elevations on sharp dry south facing ridge-tops and spurs (Brose and Waldrop 2006b). There are two schools of thought concerning the origin of these communities (Randles et al. 2002; Waldrop et al. 2003; Brose and Waldrop 2006b):

> (1) They originated from a single intense disturbance (fire, winthrow, harvest, or grazing) resulting in a unimodal diameter distribution. These stands are primarily even-aged with residual older trees that survived the stand initiating disturbance. This theory typifies the majority of post 20th century pitch and Table Mountain stands on the Nantahala and Pisgah NFs.
>
> (2) A combination of repeated light to medium disturbances in the understory (periodic surface fires) and complimentary overstory disturbances (wind, ice, snow, insects) maintained a polymodal stand structure. These stands are all-aged and are non-clumped in their structural development. This theory describes the assumed condition of pre 20th-century stands or those that avoided logging or associated catastrophic wildfire disturbance due to remote inaccessible location.

Regardless, most agree that pitch and table mountain pines are pioneer species that establish after disturbance of some intensity, primarily fire (Williams and Johnson 1992; Abrams and Orwig 1995; Vose et al. 1997; Welch et al. 2000; Waldrop et al. 2003). The abundance of even-aged stands present on the landscape initially drove the original school of thought towards pitch and Table Mountain stands requiring intense fire disturbance to successfully regenerate them. Though intense fires do occur at these sites and pine regeneration does become established it is not known if intense disturbance was more common than lower intensity fires (Brose et al. 2002; Randles et al. 2002; Waldrop et al. 2003; Jenkins et al. 2011). Cones of both pitch and Table Mountain pines are noted to drop seeds in the absence of fire at levels adequate to sustain the existing canopy compositions (Williams and Johnson 1992).

There is evidence that stand structural conditions prior to the exploitive logging period were less dense and more uneven-aged in nature (Waldrop et al. 2000) than curretnt conditions. The previously assumed stand replacing fire needed to regenerate table mountain pine is in question (Brose et al. 2002; Randles et al. 2002). Table Mountain pine and pitch pine are not nearly as dependent on high intensity fire on xeric sites that can support hardwoods (Waldrop et al. 2003; Brose and Waldrop 2006b; Jenkins et al. 2011). Under pre-settlement conditions frequent low to moderate intensity fires opened the overstory providing sunlight to the forest floor, opened serotinous cones, maintained reduced duff layers and occasionally exposed mineral soil (Waldrop et al. 2000). Pre-Euro American settlement disturbances including lightning and anthropogenic burning maintained a dramatically different ecosystem (Table 38, shaded row). Commonly, American chestnut made up a greater portion of the main canopy (10 to 61% of the stocking) (Brose et al. 2002; McNabb personal communication 2012).

Figure 92. View of composite FIA data taken within the pine-oak/heath ecozone during the stem exclusion stage.



Current stand structure has stemmed from post-European land use and fire suppression allowing oaks to expand their prevalence and traditionally fire-intolerant pines to occupy greater proportions of the overstory community (Table 38, Figure 92) (Waldrop et al 2003). Red maple (& other mesic species) started to invade after disturbances at turn of the 19th century (sanitation logging of acidic cove or intense fire), but before mountain laurel was in control of the understory (Brose et al. 2002). Though mesic species (pine and hardwoods) are not highly competitive on the driest sites to date, they are present in the understory and midstory (midstory & understory section of Table 38, Figure 92).

Mountain laurel became more aggressive on sites after *A. chestnut* lost overstory dominance. Periodic fire through the 1950s continued pitch and Table Mountain pine establishment (Brose and Waldrop 2006b), but little pine or hardwood species have been found to be regenerating since then (Waldrop et al. 2000). The dominance of mountain laurel in the understory has prevented all tree regeneration after the 1950s (Vose et al. 1997; Brose et al. 2002; Dumas et al. 2007; Jenkins et al. 2011) (understory section of Table 38). Sixty-three percent of the Nantahala and Pisgah NF acres in the pine-oak/heath ecozone have greater than 50% shrub density (Table 40). Even in contemporary stands, single occurrence fires will remove high percentages of the laurel understory (59-78%, temporarily) while multiple burns create more open forest conditions with less cover of shrubs and saplings (Randles et al. 2002; Dumas et al. 2006). Without repeated burning, hardwood and ericaceous sprouts will continue to sprout and dominate the site (Elliott et al. 2012)).

Current conditions, including a maturing canopy with little tree recruitment from the midstory through the dense mountain laurel understory, have led to the patchy overstory conditions as trees succumb to disturbance-related mortality. The majority of canopy heights measured in the 18 counties are between 51 and 75 feet tall (Table 39). Attacks by southern pine beetle have also aided in the development of current structural conditions. These overstory dynamics continue to perpetuate the aggressive mountain laurel understory which may eventually lead to the development of laurel-dominated areas with little remaining tree overstory (Brose et al. 2002).

Table 38. Comparison of canopy condition on pine oak heath represented sites studied in the literature.

Characteristics	Overstory	Midstory	Understory	Researcher/ Location
Main:	PP, TMP, CO	CO, SO, BG, RM	Mtn. Laurel	Brose and Waldrop 2006a Brose and Waldrop 2006b Georgia, South Carolina, Tennessee
Secondary:	SO, SLP, VP	No Pine	None	
Structure:	Patchy	Uniform	Variable	
Height:	50 to 65 feet	10 to 40 feet	3 to 10 feet	
Abundance:	1,100 – 1,400 stems/ac			
Dominance:	130 to 175 BA/ac			
Main:	TMP, CO	SO, BG, RM	Mtn. Laurel	Brose et al. 2002 Georgia
Secondary:	PP, SO	No Pine	None	
Structure:	Broken	Uniform	67 % Cover	
Height:	----	-----	Up to 8.5 feet	
Main:	PP, VP		BG,WP,VP, RM	Jenkins et al. 2011 Tennessee
Secondary:	SLP, Oak Spp,		Mtn. Laurel, Vac	
Structure:	----		Well developed	
Abundance:	183 stems/ac		671 stems/ac	
Dominance:	109 BA/ac		35 BA/ac	
Main:	SO,WO,RM,OA		Mtn. Laurel	Dumas et al. 2007 North Carolina
Secondary:	WP,BG,PP,CO		RM, BG, OA	
Structure:	----		Dense	

Characteristics	Overstory	Midstory	Understory	Researcher/ Location
Abundance: Dominance:	252 stems/ac 107 BA/ac		1,355 stems/ac 39 BA/ac	
Main: Secondary: Height:	PP, CO SO, BG ----	BJO SA,BO ----	Mtn. Laurel OA 5 to 13 feet	Welch et al. 2000 North Carolina
Abundance: Dominance:	364 stems/ac 127 BA/ac	385 stems/ac 14 BA/ac	693 stems/ac ----	
Main: Secondary: Height:	PP, TMP BG, VP ----	BG OA,RM ----	SA,CO Mtn. Laurel, Huc 2 to 7.5 feet	Welch et al. 2000 Virginia
Abundance: Dominance:	294 stems/ac 98 BA/ac	338 stems/ac 15 BA/ac	587 stems/ac ----	
Main: Secondary: Structure:	AC TMP,PP,CO,SO Closed, UEAM	---- ---- Open, Variable	---- ---- Open, Variable	Waldrop et al. 2000 Brose et al. 2002

Notes: Shaded row represents potential pre-European condition description. PP = Pitch Pine, TMP = Table Mountain Pine, CO = Chestnut Oak, SO = Scarlet Oak, SLP = Shortleaf Pine, VP= Virginia Pine, BG = Black Gum, RM = Red Maple, AC = American Chestnut, BJO = Blackjack oak, OA = Sourwood, SA = Sassafras, BO = Black Oak, Huc = Huckleberry spp., Vac = Blueberry spp.

Table 39. LiDAR-derived canopy height classes for the pine-oak/heath ecozone and the percentage of ownership within each class.

	Canopy Height Classes in Percent (ft)						
Ownership	1 – 10	11 – 20	21 to 40	41 to 50	51 to 75	76 to 100	101 Plus
Nantahala & Pisgah	3%	4%	18%	15%	40%	16%	2%
Non – Forest Service	8%	4%	12%	11%	38%	24%	3%

Table 40. LiDAR-derived shrub density classes for the pine-oak/heath ecozone and the percentage of ownership within each class (0 to 15 feet tall).

Ownership	0-25%	26-50%	50-75%	>75%
Nantahala & Pisgah	12%	25%	32%	31%
Non – Forest Service	21%	30%	28%	22%

Figure 93. Composite FIA plots from the pine-oak/heath ecozone showing abundance and dominance of selected species groups at the onset of stem exclusion.

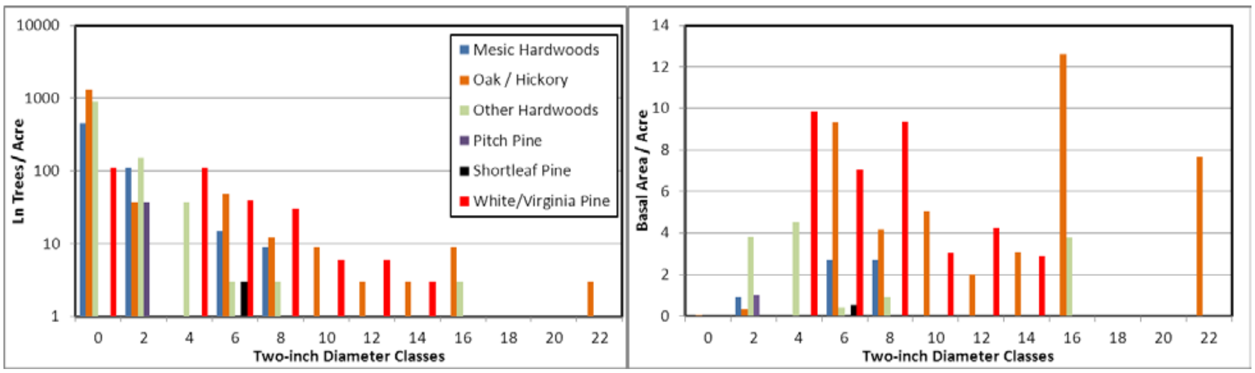


Table 41. Nantahala & Pisgah NFs pine-oak/heath ecozone current silvicultural age class distribution.

Silvicultural Age Class	Closed Canopy Acres (%)	Open Acres (%)	Total (%)
1 to 10	456 (0)	6 (0)	0
11 to 20	1147 (1)	0 (0)	1
21 to 30	4980 (5)	12 (0)	5
31 to 40	3333 (3)	12 (0)	3
41 to 50	1831 (2)	191 (0)	2
51 to 60	1145 (1)	115 (0)	1
61 to 70	1269 (1)	297 (1)	2
71 to 80	6503 (6)	1765 (2)	8
81 to 90	13737 (14)	5611 (6)	19
91 to 100	13514 (13)	8719 (9)	22
101 to 110	7274 (7)	4713 (5)	12
111 to 120	3517 (3)	2908 (3)	6
121 to 130	3129 (3)	3671 (4)	7
131 to 150	2599 (3)	2085 (2)	5
151 to 200	1139 (1)	828 (1)	2
200 Plus	40 (0)	83 (0)	0
No Data	4,538		4

Silvicultural Age Class	Closed Canopy Acres (%)	Open Acres (%)	Total (%)
Totals	101,169		100

More than half of the national forest lands in the pine-oak/heath ecozone were established between 1903 and 1932. The single decade with the most young forest habitat creation was 1913 to 1922 (22%) (Table 41). Even if stands could not be logged due to terrain-limited access, many of these sites still received stand-replacing fires that may have started in other portions of the landscape but culminated on dry rocky south-facing slopes occupied by these stands.

A bimodal age class distribution is present in the pine-oak/heath ecozone with young forest habitat conditions being created from 1983 to 1992. Management constraints such as poor access, low commercial value, and elevated scenic values have limited management options in the most recent decade. Roughly 30% of the pine-oak/heath ecozone is within a currently designated area.

Closed canopy conditions dominate the mid and mature forest stages (Figure 95, Table 42). Open and closed conditions in the old growth stage are more balanced highlighting the increased influence of disturbances and site productivity on the stands in this ecozone. Young forest habitat accounts for a small proportion of the habitat conditions present, while a larger portion of the stands in North Carolina are entering later seral stages (understory reinitiation), similar to the Southern Appalachians as a whole (Waldrop et al. 2003).

Figure 94. Nantahala & Pisgah NFs pine-oak/heath ecozone current silvicultural age class distribution.

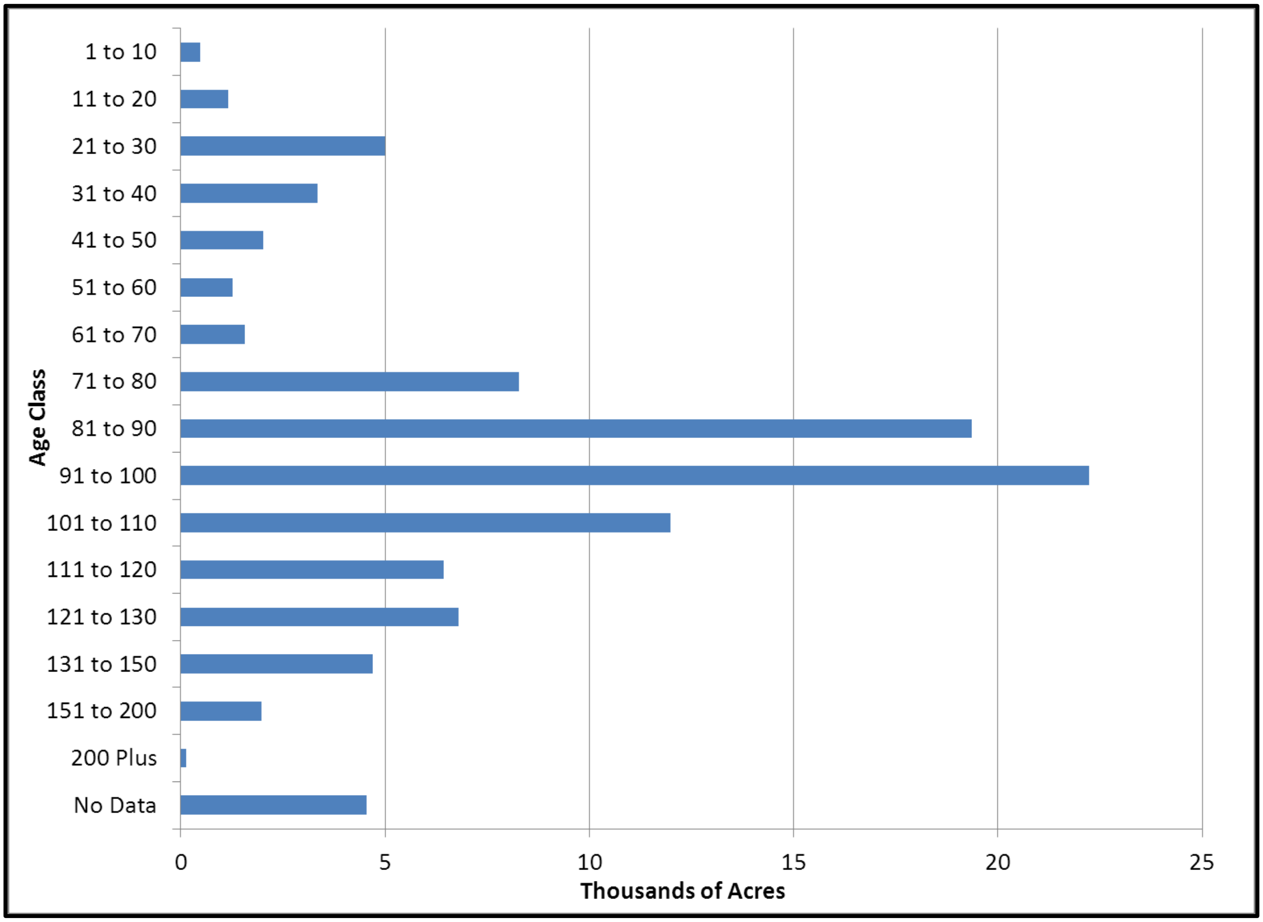
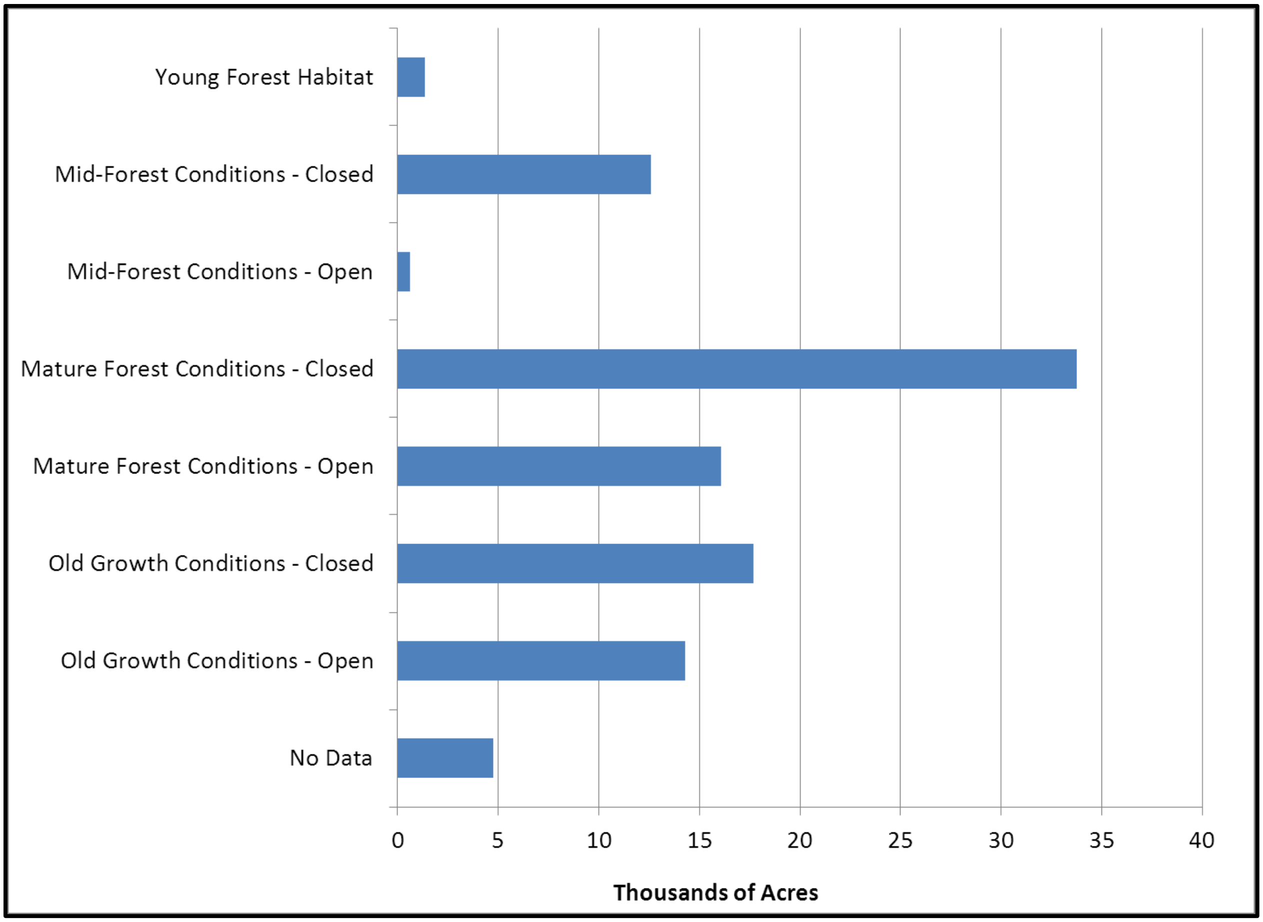


Table 42. Nantahala and Pisgah NFs pine-oak/heath ecozone current BpS age structure class conditions.

Age Structure Class	Age Range	Acres	% of Total Ecozone
Young Forest Habitat	1 to 19	1,358	1
Mid-Forest Conditions - Closed	20 to 70	12,583	12
Mid-Forest Conditions - Open	20 to 70	628	1
Mature Forest Conditions - Closed	71 to 100	33,754	33
Mature Forest Conditions - Open	71 to 100	16,095	16
Old Growth Conditions - Closed	101 Plus	17,698	17
Old Growth Conditions - Open	101 Plus	14,289	14
No Data	---	4,765	5
Totals	All	101,169	100

Figure 95. Nantahala and Pisgah NFs pine-oak/heath ecozone current BpS age structure class conditions.



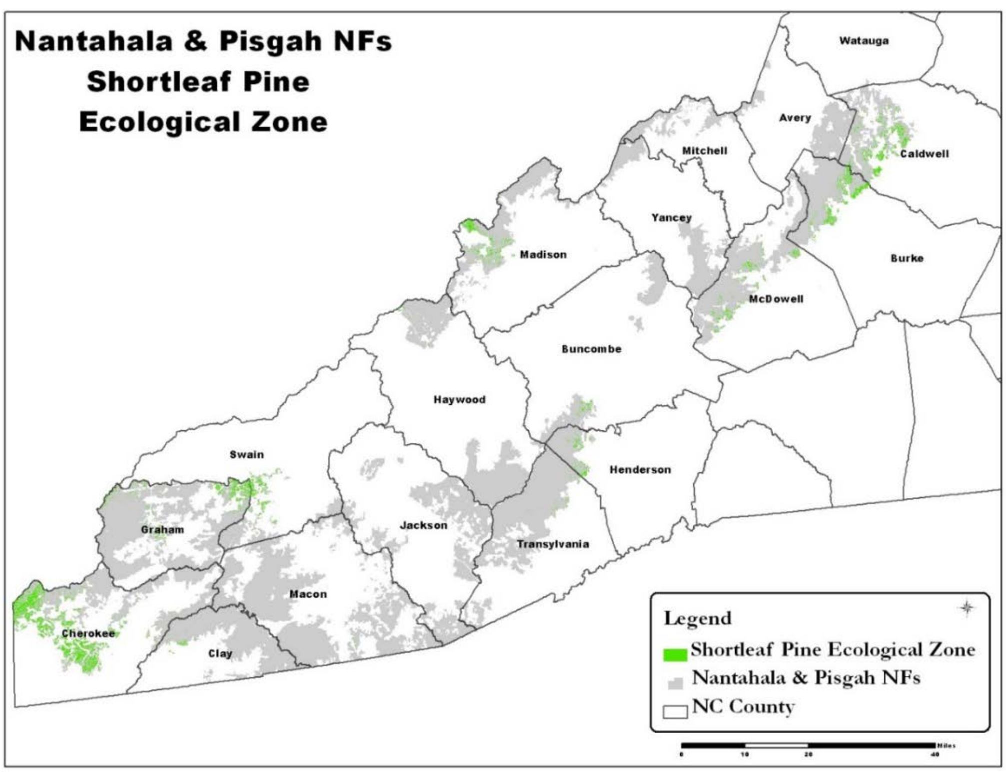
Shortleaf Pine Ecological Zone

Geographic Setting: The ecological zone is only located at low elevations, typically below 2,300 feet (Natureserve 2013). It occurs on exposed slopes, low hills, and ridges. Soils are typically acidic, with a pH 4.1 to 4.3, as they are limited to acidic substrates (Natureserve 2013, Carolina Vegetation Survey 2013). Wind storms, tornadoes, insect infestations, and frequent wildfires are all important natural disturbance events influencing this zone.

Geographic Distribution: This low elevation ecozone covers about 44,450 acres or 4.3% of the Nantahala and Pisgah NFs (Figure 96). In the surrounding 18-county area the ecozone covers about 8.9% of the land base. This zone occurs along the southern most extent of the Southern Blue Ridge across South Carolina, Georgia, North Carolina, and Tennessee, extends into the southern Ridge, Valley, and Cumberland Plateau of Tennessee and Kentucky, and possibly ranges into the upper Piedmont (Natureserve 2013). Three or four subtypes have been distinguished based on composition and a more open canopy. The two shortleaf pine dominated ecotypes are considered secure with a rank of G4 while the mixed pine-oak subtypes, forest and woodlands, are less abundant with a G3 rank (Natureserve 2013).

In western North Carolina, this ecozone is restricted to low elevation areas in the Hiwassee River, the Little Tennessee River, the French Broad River, the Catawba River and the Broad River valleys. The ecozone is very sparse within Jackson, Haywood, Yancey, Mitchell, Watauga, and Avery counties.

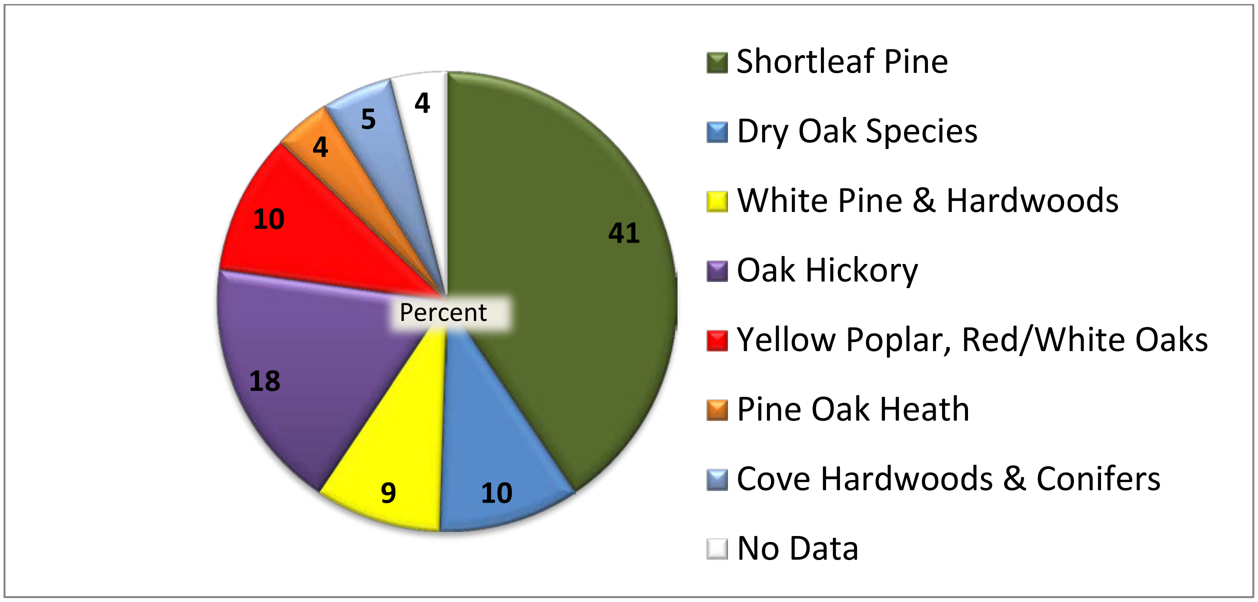
Figure 96. Distribution of shortleaf pine ecozone across the Nantahala and Pisgah NFs.



FSVeg Types

Within Nantahala and Pisgah NFs, the vegetation management database identifies 17,288 acres with components of the shortleaf pine community. These acres represent approximately 41% of the ecozone (Figure 97). Adjacent communities including oak/hickory, yellow poplar, red/white oak, and others make up another 55% of the ecozone (TNC 2007e). Roughly, 9% of the ecozone contains forest types that may represent a disturbed condition.

Figure 97. Nantahala & Pisgah NFs FSVeg forest type breakdown within the shortleaf pine ecozone



Composition

The shortleaf pine ecozone is dominated by shortleaf pine (*Pinus echinata*) with lesser amounts of southern red oak (*Quercus falcata*), pitch pine, chestnut oak, scarlet oak, blackjack oak (*Quercus marilandica*), post oak (*Quercus stellata*), white oak, pignut hickory, red hickory, and red maple within the shortleaf pine subtype (Simon 1996; Schafale 2012). Shortleaf pine is not dominant within the montane and mixed pine-oak subtypes, rather co-dominant with pitch pine in the former and with numerous oaks in the latter.

Many sites with these subtypes, particularly those with no recent fire occurrences, have a dense shrub layer, this typically dominated by ericaceous species such as mountain laurel, low bush blueberry or bear huckleberry. Scattered herbs within the more closed shrub layer include stiffleaf coreopsis (*Coreopsis major var. rigida*), wintergreen (*Gaultheria procumbens*), trailing arbutus (*Epigaea repens*), rattlesnake orchid (*Goodyera pubescens*), *Dichanthelium commutatum*, rattlesnake-weed (*Hieracium venosum*), bracken fern (*Pteridium aquilinum*), and whorled loosestrife (*Lysimachia quadrifolia*). Where all three subtypes have been under a more frequent prescribed burn management, the shrub layer can be quite open, with only scattered shrub occurrences. One shrub that seems to like the more frequent fire is New Jersey tea (*Ceanothus americanus*). Within these more open areas the herbaceous layer tends to be diverse and includes such species as fragrant goldenrod (*Solidago odora*), grey goldenrod (*Solidago* *nemoralis*), stiff aster (*Ionactis linariifolius*), little bluestem, Indian grass (*Sorghastrum nutans*), grass-leaved golden-aster (*Pityopsis graminifolia*), Maryland golden-aster (*Chrysopsis mariana*), tick-trefoil (*Desmodium laevigatum*), hairy lespedeza (*Lespedeza hirta*), wand lespedeza (*L. intermedia*), trailing lespedeza (*L. repens*), rosin-weed (*Silphium compositum*), hairy angelica (*Angelica venenosa*), black-eyed Susan (*Rudbeckia hirta*), goat's-rue (*Tephrosia virginiana*), butterfly pea (*Clitoria mariana*), late eupatorium (*Eupatorium serotinum*), sensitive brier (*Schrankia microphylla*), partridge-pea (*Chamaecrista fasiculata*), Appalachian sunflower (*Helianthus atrorubens*), silver plume grass (*Saccharum alopecuroideum*), and *Baptisia tinctoria*. Herbaceous diversity can be sparse under the densest shrub layer and can account for sites recorded with 20 vascular plant species (Ulrey 1999). However, a more open fire-maintained habitat can have as many as 70 plants (G. Kauffman, personal communication)

Connectedness

The ecozone is variable although it typically occurs on the most xeric portion of the landscape. It can be upslope of either rich cove, acidic cove, mesic oak or dry-mesic oak forest. Patch sizes of this ecozone are variable from ten or fewer acres in isolated patches to hundreds of acres across the connected undulating ridges at low elevation. This ecozone is limited across the Nantahala and Pisgah NFs and frequently burned high quality open or partially open habitat is sparse. As a result, fire-loving species that occur within this ecozone can be widely dispersed or only occur in very small population sizes. In particular, fire-adapted grasses, legumes, and aster family members are patchy and often consist of small populations.

Designated Areas

Only a small portion, 6.3%, of this low elevation ecozone is currently within existing designated areas. This ecological zone is the least represented within all the designated areas. The majority of the represented acres are in the Bent Creek area and Joyce Kilmer Wilderness.

Disturbance Dynamics

Openings within this forest are generally driven by insect occurrences, in particular southern pine beetle, wind events, and fire. The last southern pine beetle infestation occurred across both forests in the late 1990s. Patch sizes can vary dramatically depending on insect outbreaks and if they are followed by fire events, which can lead to large openings. Fire is considered an important factor in maintaining this habitat with a fire return frequency as low as four years (Landfire 2009). The absence or infrequency of fire can result in more canopy oak dominance, an increase in fire intolerant trees such as red maple, and an increase in shrub density.

Based on LiDAR analysis of the shrub canopy density, a more open understory with greater than 50% shrub coverage extends across about 45% for the ecozone. This closed portion would represent areas with infrequent or no recent fire events, wildfires or prescribed burns. During the last seven years across the Nantahala and Pisgah NFs, prescribed burns have occurred on 7,329 acres within the shortleaf pine ecozone, representing approximately 16.5% of this ecozone.

Nonnative Invasive Plant Species

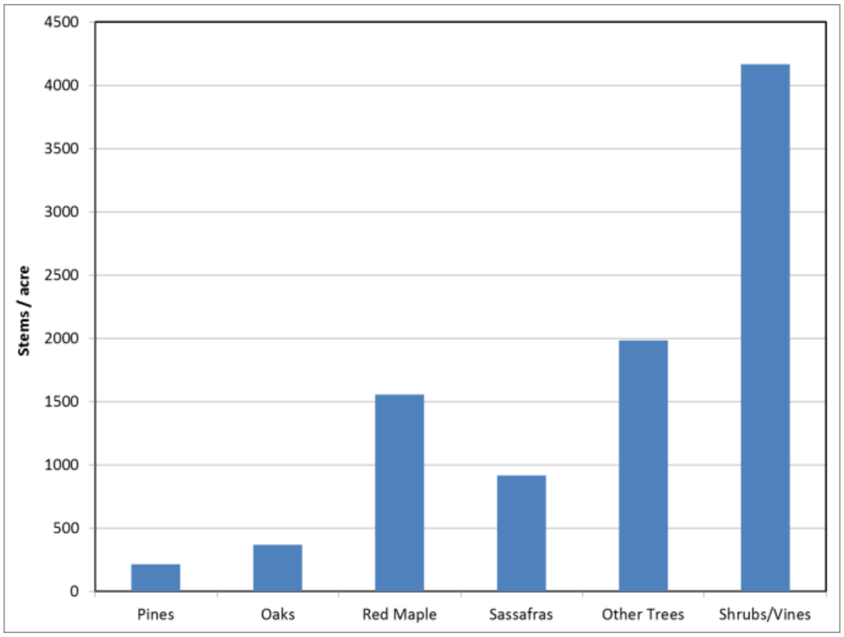
Compared to other ecozones, few invasive non-native plant species have been located within the shortleaf pine ecozone. Small infestations of Chinese silvergrass, spotted knapweed, and princess tree have been located within more open shortleaf pine forest based on Forest Service inventories in the Nantahala and Pisgah NFs, typically those with recent disturbances such as southern pine beetles or prescribed burns.

Shortleaf Pine Vegetation Structure

Many low elevation shortleaf pine hardwood stands likely had their origins in agricultural land abandonment in the presence of a frequent low intensity fire regime in the early 1900s (Vose et al. 1997). The lower elevation sites that this ecozone occupies are generally gentler in topography and were more readily accessible to early settlers to develop as pasture and farmland. Unfortunately these sites typically have lower productivity (parent material) and could not sustain settlers in the area, which resulted in rapid abandonment. Other portions of the landscape were allowed to revert back to forest as lands were purchased by the Vanderbilts or acquired under the Weeks Act and transferred to the Nantahala and Pisgah NFs and the Great Smoky Mountains National Park (Nesbitt 1941; Guyon et al. 2003).

Both components of this ecozone (shortleaf pine and oak) are at risk from different groups of species that threaten to change not only the long-term composition of the ecozone but also its structure. As discussed in the description of oak ecozones, oak species are at risk of encroachment by mesic hardwood species in all canopy layers (Nowacki and Abrams 2008). Composite forest inventory analysis plots within this ecozone indicate stands within the stem exclusion stage contain an abundance of mesic hardwood species across a range of size classes (Figure 98). The mesic species express dominance in all but the largest sizes classes (Table 43). Oak and hickory species are present in these plots but in the smallest sizes contribute little to the abundance and dominance and do not have the competitive advantage to advance into the upper canopy (Loftis 1990).

Figure 98. Average understory woody vegetation density in for shortleaf pine hardwood study sites post SPB attack in eastern Tennessee (adapted from Elliott et al. 2012).



In addition to the oak and hickory species regeneration gap, the shortleaf pine is losing ground to other conifer species capable of invading sites in the absence of fire. Both white and Virginia pines are known to be field invaders in the absence of fire, and white pine is especially aggressive where its moderate shade tolerance allows it to gain a foothold under an existing canopy (Elliott and Vose 2005). These conditions have been accentuated in recent decades due to increased canopy openings on relatively low quality sites and attacks from the southern pine beetle (Elliott et al. 2012). White and Virginia pines are abundant and hold considerable dominance in the middle size classes of both young and maturing forests (Figures 99). On some sites they are dominant throughout the stand structure (Table 44).

Mesic species are also present in older stands where the understory has reinitiated. They are most abundant on composite FIA plots, while shortleaf pine and oak hickory species dominate the larger size classes and the main canopy (Figure 101). Shortleaf pine and oak are poorly represented in the smallest size classes (i.e. understory) while the abundance is dominated by combinations of other species, groups or vines (Figures 100, 101).

These dual-threat compositional shifts have drastically altered the structure of the forests in the shortleaf pine-oak ecozone. Current forest structures have higher densities throughout all canopy layers. Consequently, less sunlight reaches the forest floor reducing herbaceous species which are also suffering from fire suppression. These denser, more mesic structural conditions are also slowly shifting the forest floor composition and structure with mesic detritus inputs (Nowacki and Abrams 2008; Arthur et al. 2012). Similar to the pitch/Table Mountain pine stands found in the pine oak heath ecozone, mountain laurel has also taken advantage of restricted fire within these ecozones to expand, further altering the mid-story structure and making it more dense while contributing to reductions in understory herbaceous and woody structure. In the shortleaf pine-oak ecozone, 22-29% of the national forest and non-national forest lands are in the 51-75% shrub density class, and another 35% are in the 26-50% density class (Table 44).

Table 17. LiDAR-derived canopy height classes for the shortleaf pine-oak ecozone and the percentage of ownership within each class.

	Canopy Height Classes in Percent (ft)						
Ownership	1 – 10	11 – 20	21 to 40	41 to 50	51 to 75	76 to 100	101 Plus
Nantahala & Pisgah	4%	4%	15%	11%	41%	22%	3%
Non – Forest Service	13%	6%	14%	11%	39%	16%	1%

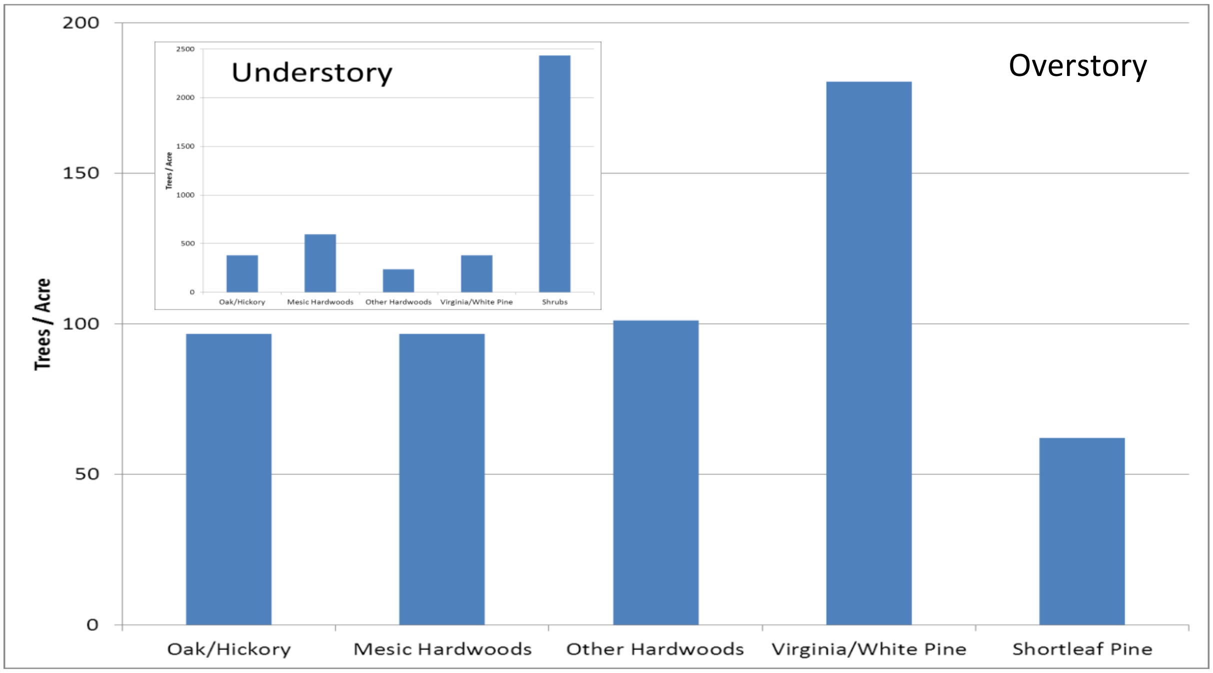
Table 18. LiDAR-derived shrub density classes for the shortleaf pine-oak ecozone and the percentage of ownership within each class (0 to 15 feet tall).

Ownership	**0-25%**	**26-50%**	**50-75%**	**>75%**
Nantahala & Pisgah	20%	35%	29%	15%
Non – Forest Service	32%	35%	22%	11%

Table 19. Average canopy conditions on shortleaf pine sites studied in the literature.

Characteristics	**Overstory**	**Understory (seedlings/saplings)**	**Researcher/ Location**
Main:	VP,SLP, WO	RM,WP, Mtn. Laurel	
Secondary:	RM,OA,WP	Vac, BG	Elliott and Vose 2005
Abundance:	537 stems/ac	4,024 stems/ac	Georgia, Tennessee
Dominance:	145 BA/ac	2.87 BA/ac (saps)	

Figure 99. Average overstory and understory abundance from shortleaf pine study sites in Georgia and Tennessee (adapted from Elliott and Vose 2005).



Shortleaf Pine Ecozone Structure Descriptive Summary

Overstory: Increasingly scattered shortleaf pine overstory with a patchy to continuous oak dominated canopy with variable mesic pine and hardwood species present in main canopy gaps or the midstory. Average canopy heights range from > 50 to < 100 feet (Table 36).

Understory: Scattered or clumped ericaceous shrubs and small trees with patchy hardwood regeneration. There is little to no shortleaf pine regeneration with dense clumps of white pine regeneration and variable herbaceous species abundance.

Figure 100. Composite FIA plots from the shortleaf pine-oak ecozone showing abundance and dominance of selected species groups at the onset of stem exclusion.

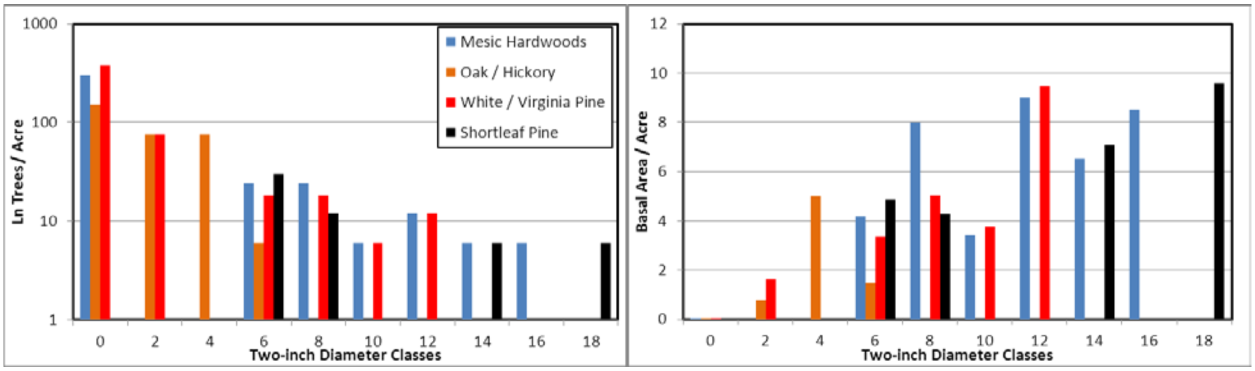
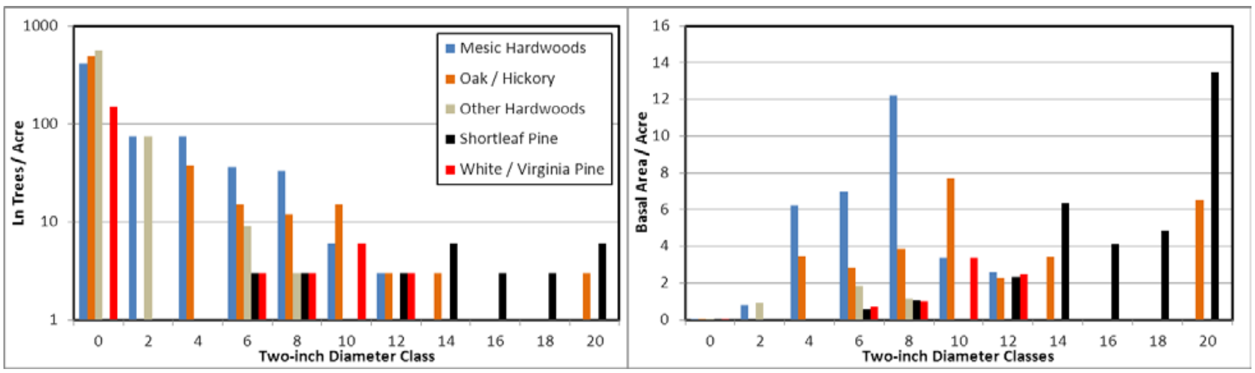


Figure 101. Composite FIA plots from the shortleaf pine-oak ecozone showing abundance and dominance of selected species groups during understory reinitiation.



Age Class

Lands that make up the shortleaf pine-oak ecozone show the strongest bimodal age class distribution of the eleven ecozones. The largest proportions of the shortleaf oak ecozones were established between 1913 and 1932 (17% each decade) (Table 46). While regeneration usually implies the harvesting of timber, the location of the shortleaf pine-oak ecozone also indicates a complex land use history including subsistence farming, grazing, and subsequent land abandonment or purchase/acquisition by the National Forest System and National Park System, all of which occurred during the same time period.

The second peak in regeneration occurs between the early 1960s and the early 1990s. Higher amounts of harvesting and early age class creation in the shortleaf pine ecozone during this period are likely related to lower elevation and greater access to lands within this ecozone. Southern pine beetle may have also played an important role in the creation of early age classes in the late 1980s and early 1990s as pines were salvaged after they were killed. These activities continued into the early 2000s, showing roughly 1% of the ecozone in the 1-10 year age-class (Table 46).

The shortleaf pine-oak ecozone has few documented acres in age classes greater than 150 years old (Table 46).

Figure 102. View of composite FIA data taken within the shortleaf pine-oak ecozone during the stem exclusion stage.

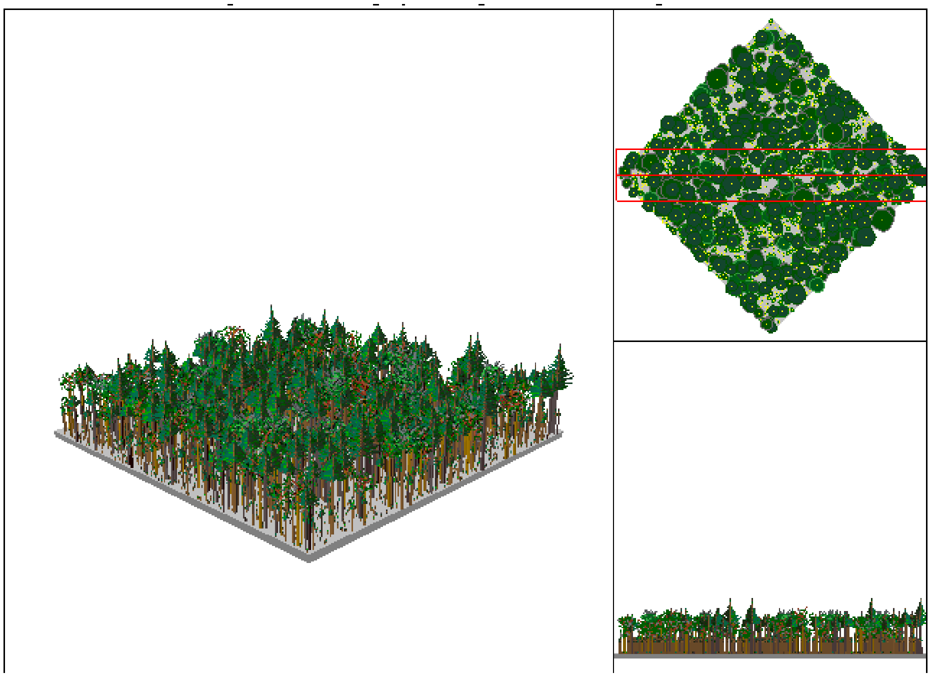


Figure 103. View of composite FIA data taken within the shortleaf pine-oak ecozone during the complex stage.

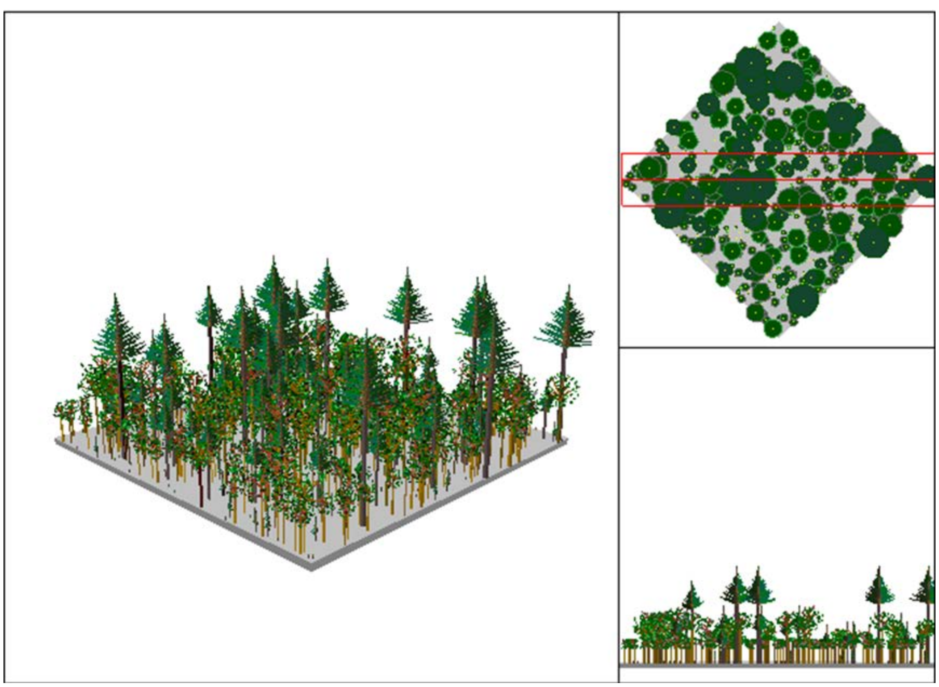


Table 20. Nantahala & Pisgah NFs shortleaf oak ecozone current silvicultural age class distribution.

Silvicultural Age Class	Closed Acres (%)	Open Acres (%)	Total (%)
1 to 10	625 (1)	18 (0)	1
11 to 20	1,899 (4)	15 (0)	4
21 to 30	4,326 (10)	16 (0)	10
31 to 40	3,233 (7)	0 (0)	7
41 to 50	3,431 (8)	32 (0)	8
51 to 60	493 (1)	24 (0)	1
61 to 70	848 (2)	38 (0)	2
71 to 80	4,095 (9)	728 (2)	11
81 to 90	6,029 (14)	1335 (3)	17
91 to 100	5,443 (12)	2313 (5)	17
101 to 110	2,773 (6)	1485 (3)	10
111 to 120	1,145 (3)	425 (1)	4
121 to 130	537 (1)	198 (0)	2
131 to 150	559 (1)	213 (0)	2
151 to 200	39 (0)	13 (0)	0
200 Plus	0 (0)	0 (0)	0
No Data	2,091		5
Grand Total	44,418		100

Figure 104. Nantahala & Pisgah NFs shortleaf oak ecozone current silvicultural age class distribution.

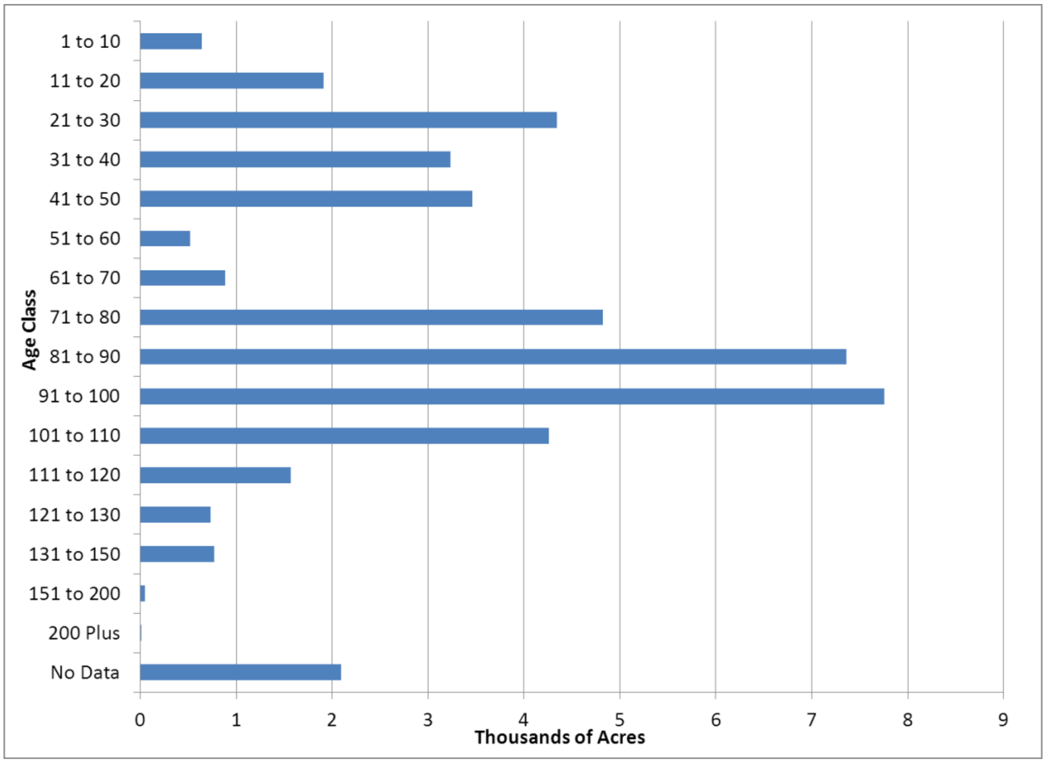
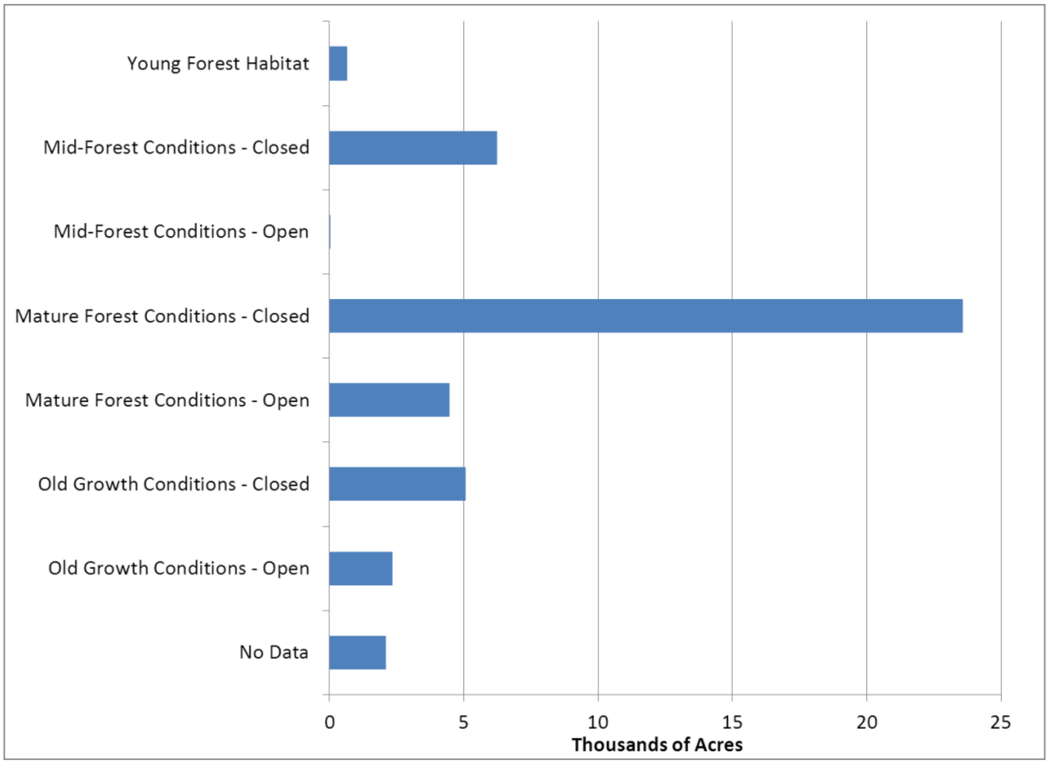


Table 21. Nantahala and Pisgah NFs shortleaf pine-oak ecozone current BpS age structure class conditions.

Age Structure Class	Age Range	Acres	% of Total Ecozone
Young Forest Habitat	1 to 10	643	1
Mid-Forest Conditions – Closed	11 to 30	6,225	14
Mid-Forest Conditions – Open	11 to 30	31	0
Mature Forest Conditions - Closed	31 to 100	23,571	53
Mature Forest Conditions - Open	31 to 100	4,470	10
Old Growth Conditions - Closed	101 Plus	5,053	11
Old Growth Conditions - Open	101 Plus	2,334	5
No Data	---	2,091	5
Totals	All	44,418	100

As with the other ecozones, closed canopy conditions are dominant (77%) throughout second growth forest conditions, especially the mature forest conditions, which make up over half of the acres in this ecozone (Figure 105, Table 47). Less than 20% of the ecozone is in old growth conditions.

Figure 105. Nantahala and Pisgah NFs shortleaf pine-oak ecozone current BpS age structure class conditions.



Shortleaf Pine Terrestrial Wildlife

Southern yellow pines occur throughout the Southern Appalachians, but are more localized in the mountains. Historically, sizable areas of southern yellow pine forests in the southern and western portions of the Southern Blue Ridge (SBR) Ecoregion (potentially including parts of the Nantahala and Pisgah NFs) supported remnant family groups of red-cockaded woodpecker and small populations of Bachman's sparrow, neither of which presently occur within the physiographic area.

The value of mountain yellow pine habitats for vulnerable birds, other than early successional species, is poorly understood, as few studies have been conducted in these areas. Bartlett (1995) found that mature yellow and mixed pine-hardwood stands were less diverse and supported fewer migrant and resident bird species than other deciduous upland forest types in the mountains of Tennessee. However, some mature yellow pine forests, especially those mixed with hardwoods or containing a dense shrub layer, provide optimal breeding habitat for several vulnerable species that occur in other mature forests in the SBR including ovenbird, eastern wood-pewee, as well as several woodpecker species.

Additionally, recently harvested pine stands along with young oak hardwood regeneration provide essential habitats for many priority early successional species, including the prairie warbler, as well as locally important populations of ruffed grouse, northern bobwhite, and wild turkey. Local subspecies of red crossbill may depend on stands dominated by yellow pines at middle elevations during some years, but more information is needed on whether these forests are equivalent to hemlock, white pine, and spruce as important food sources (Groth 1988).

Southern yellow pine forests may provide important winter habitat for several high priority resident and short distance migrant species. Hamel (1992) identified late successional mixed-pine hardwoods as optimal habitat for yellow-bellied sapsucker, brown creeper, red-breasted nuthatch and golden-crowned kinglet. Mature Virginia pine stands were also identified as optimal habitats for red-breasted nuthatch and golden-crowned kinglet. However, it is unclear if these forest types are important to these species in the SBR specifically. Studies addressing the use of yellow pine forests by these and other species during the winter months would help clarify the importance of pine ecosystems to the overall bird community.

Range-Wide Trends

Perhaps the most significant issue affecting pine ecozones in North Carolina is the lack of regular exposure to fire, which is needed to maintain and regenerate this habitat type (NCWAP 2005). Fire suppression, or the inability to use fire as a management tool, is resulting in a decline in both quantity and quality of pine habitats. Pine forests that are not regularly burned often develop dense mountain laurel or rhododendron understories that shade out other shrubs and herbaceous plants, thus lowering the habitat quality and diversity of wildlife which could utilize the area. Additionally, southern pine beetles are a native pest, and outbreaks occur periodically, but when these outbreaks are not followed by fire, coniferous habitat is eventually lost to drier hardwood habitats.

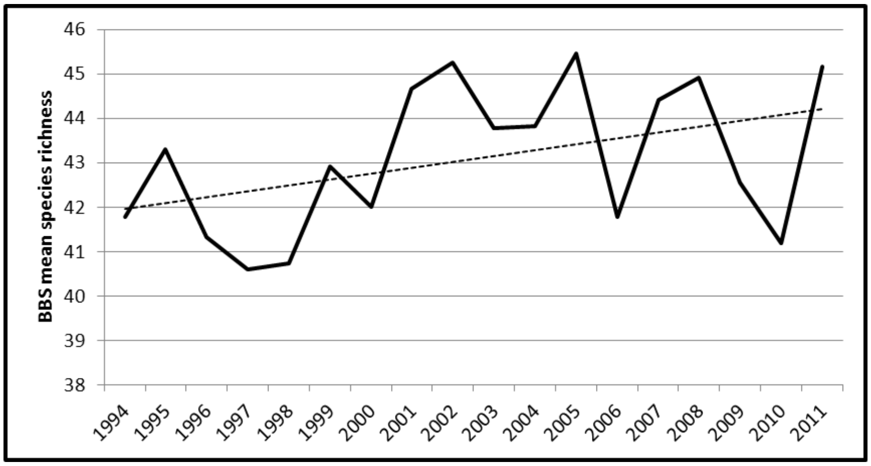
Additional problems faced by wildlife species associated with dry coniferous forest include the lack of early successional habitat of this type or conversion of this habitat to other pine habitat (i.e. white pine) for species such as prairie warblers, woodpeckers, and nuthatches. Timber rattlesnake harassment in these habitats also remains a significant threat. Lack of management of the stands decreases the quality of habitat for woodland hawks by decreasing prey abundance and limiting their ability to hunt in dense understory growth. As with many habitats, human development is rapidly decreasing the availability of this habitat across the region. Not only are we losing the habitat to development, but development in or adjacent to these sites leads to a significant problem with respect to managing these habitats with prescribed fire. Even where dry coniferous forest management could occur, we are often limited in our abilities to use fire as a management tool, due to the proximity of residential or other development (NCWAP 2005).

Where not otherwise managed for commercial production, mature southern yellow pine forests should be maintained at current levels and increased where possible (i.e. implementing an active fire management program). Otherwise, maintenance of current or increased pine acreage would be a very low bird conservation priority. In stands that are overstocked or have closed canopies, improvement techniques such as thinning, along with periodic prescribed burns, may be necessary to improve habitat for species associated with more open canopy conditions and dense understories. Such practices may be extremely important for restoring species that rely on pitch and Table Mountain pine communities, as well as other coniferous areas that are being replaced by hardwoods. Failure to actively manage pine ecosystems will likely result in permanent loss of these communities within the southern blue ridge. While specific effects of this lack of management on avian species is unknown, it is reasonable to assume that declines in general species richness and abundance would occur.

Forest-Level Trends

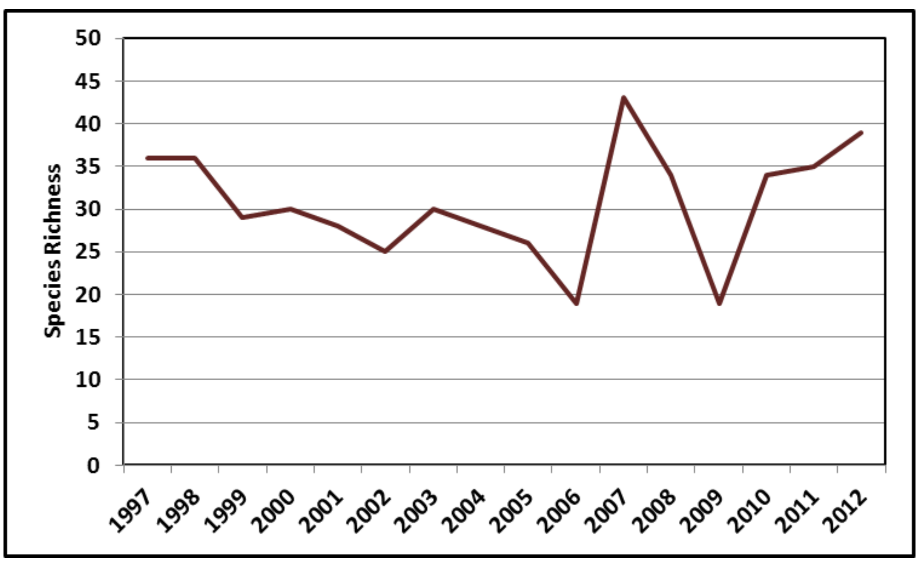
Across the Nantahala and Pisgah NFs, breeding bird survey data shows mean species richness to be stable to slightly increasing. There are 17 established routes on or across the forests, 13 of which have consistent data (Figure 106). Most of these routes traverse mesic oak and mixed pine-oak forests. This positive trend does not necessarily correlate to positive trends for individual species.

Figure 106. Mean bird species richness from BBS routes on or across the Nantahala and Pisgah NFs, 1994 through 2011 (BBS 2012).



Seventy bird species have been documented in shortleaf pine forests in the Nantahala and Pisgah NFs between 1997 and 2012 (Appendix A, USFS 2013). Within this same monitoring period, species richness within these forests has remained stable, although high annual variability is evident (Figure 107).

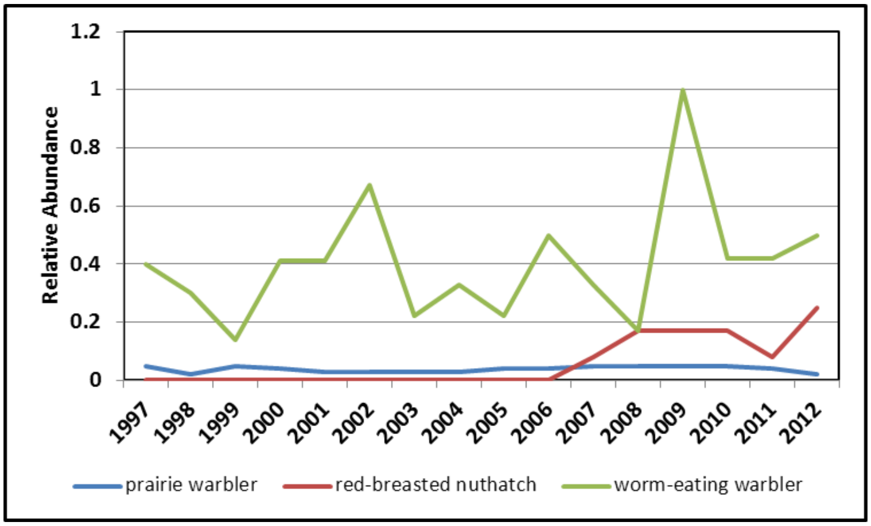
Figure 107. Landbird species richness within shortleaf pine forests on the Nantahala and Pisgah NFs, 1997-2012 (USFS 2013).



Long-term monitoring data (USFS 2013) includes two priority bird species identified in the Partners in Flight Bird Conservation Plan for the SBR (Hunter et al. 1999) associated with yellow pine forests. These species include prairie warbler (*Setophaga discolor*) and red-breasted nuthatch (*Sitta canadensis*). Additionally, the NC Wildlife Action Plan identifies prairie warbler and worm-eating warbler (*Helmitheros vermivorous*) as a priority species associated with dry coniferous woodlands.

Populations of red-breasted nuthatch and worm-eating warblers, while at low densities, are stable to slightly increasing within shortleaf pine-oak forest. Worm-eating warbler populations have exhibited high annual variability within pine ecosystems during the 16 year monitoring period. Populations of prairie warbler are stable to slightly decreasing within shortleaf pine forests during this period (Figure 108).

Figure 108. Relative abundance of bird species associated with shortleaf pine (i.e. dry coniferous forests or southern yellow pine forests), 1997 through 2012 (USFS 2013).



Long-term monitoring data (Appendix A ,USFS 2013) includes one species, pine warbler (*Setophaga pinus*), that while not identified as a priority species by Hunter et al. (1999) or NCWRC (2005), is dependent on pine and mixed pine forests. Over the last five years, the Forest Service has increased management of pine and other fire-dependent forests through the increased use of prescribed fire. Populations of pine warbler have increased steadily since 1997, although variability increased noticeably since 2006.

Generally speaking, bird populations within shortleaf pine forests are stable to very slightly increasing. Populations of almost all species associated with early successional and young forest conditions and intact canopy conditions are declining, some significantly.

Floodplain Ecological Zone

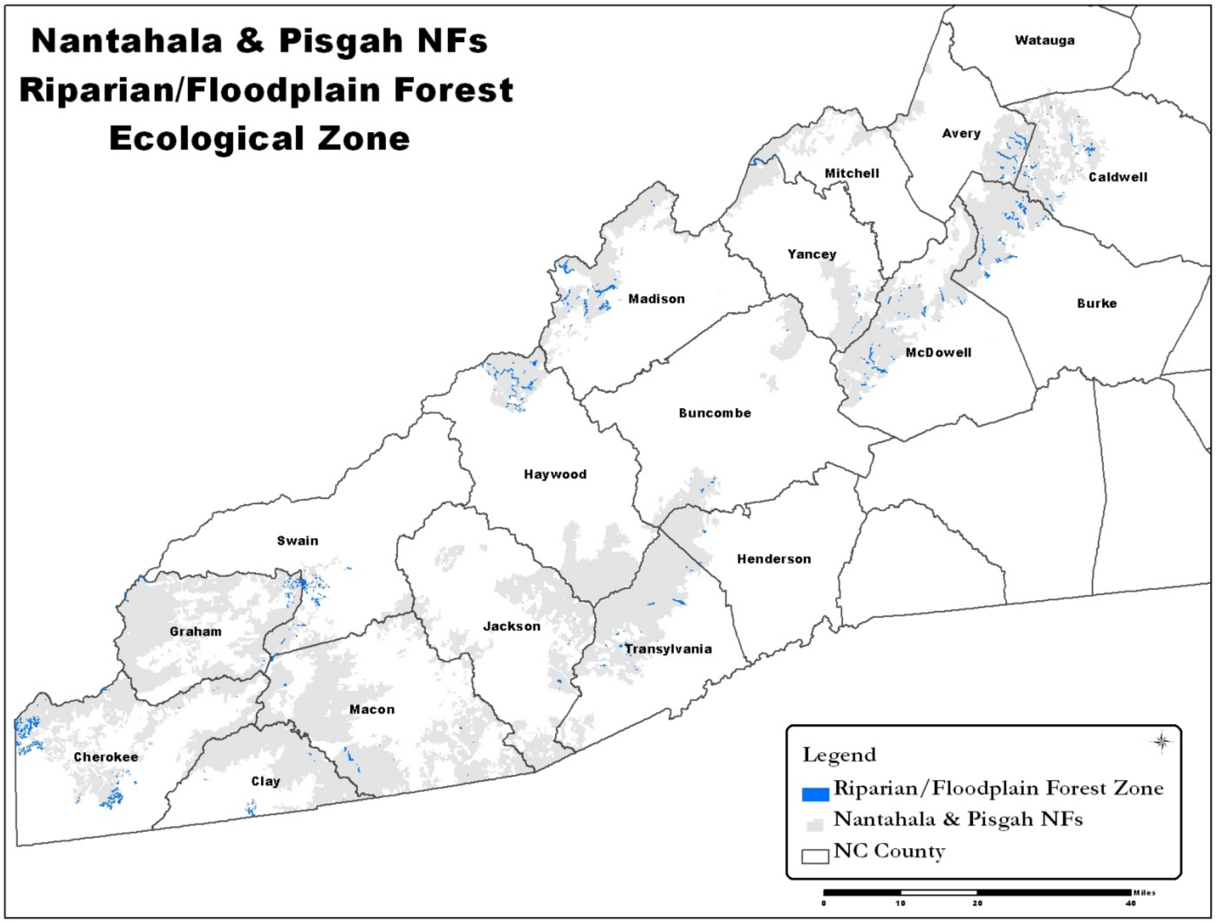
Environmental Setting: The floodplain forest ecozone is found in small and large floodplains up to an elevation of 3,000 feet, although these zones are seldom found above 2,600 feet (Biotics 2011). The larger floodplain system only occurs at lower elevations along large rivers and can have many fluvial features such as river terraces or islands, point bars, or oxbows (Simon 2011). It is influenced by frequent flooding, typically for a short duration within the small river subtype with scoured river banks. Results of the flooding can include sedimentation and eroded soils. Soils are typically sandy, silty, and acidic with low base saturation (Carolina Vegetation Survey 2013). Flooding, beaver activity, and high winds from hurricanes are the three major natural disturbance patterns influencing this ecozone.

Distribution: The large river subtype is documented from the Southern Blue Ridge in southwestern Virginia, south to northern Georgia, and west into the Cumberland Mountains of Kentucky (Natureserve 2013). In comparison, the small river subtype extends from the southern and western extents of the Blue Ridge Province in Georgia and Alabama to the heart of the Blue Ridge in North Carolina and Tennessee, and possibly into the foothills. The large river subtype is the least common of the two. It has a global rank of G2?, while the small river subtype is G3.

Across the Nantahala and Pisgah NFs the ecozone covers slightly less than 2,600 acres (Figure 109). This low elevation ecozone represents approximately 0.2% of the Nantahala and Pisgah NFs. The habitat is unevenly distributed across the Nantahala and Pisgah NFs, generally occurring below 2,500 feet elevation with concentrations across stretches of the Catawba River, the Nolichucky River, the French Broad River, the Davidson River, the Cheoah River, the Nantahala River, the Hiawassee River, Upper Creek, Curtis Creek, and Shuler Creek. It is the least represented of all the ecozones, more abundant across the surrounding 18-county area, covering about 4.1% of the land base.

Based on LiDAR analysis of the shrub canopy density, a closed understory with over 50% shrub coverage extends across more than 40% of this ecozone within the Nantahala and Pisgah NFs. In comparison, less than 25% of the ecozone has a closed shrub density in instances across 18-county area in western NC. This difference may be indicative of current land use disturbance on the private lands.

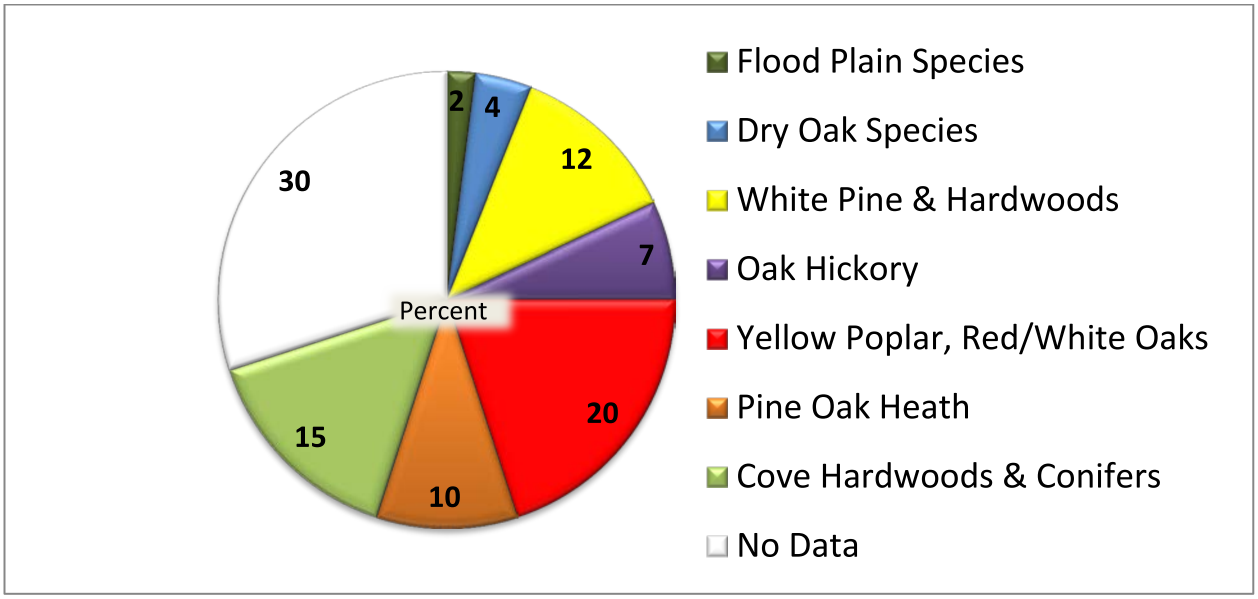
Figure 109. Distribution of Alluvial Forest Ecological Zone across the Nantahala and Pisgah NFs.



FSVeg Types

Within Nantahala and Pisgah NFs, the vegetation management database identifies 33 acres as having components of the flood plain hardwood community. These acres represent approximately 2% of the ecozone (Figure 110). A large portion (58%) of the ecozone is made up of communities that typically transition to the flood plain hardwood communities (Figure 110) (Landfire 2009). Roughly 10% of the ecozone contains the pine oak heath forest. Thirty percent of the ecozone is characterized by no data, the largest proportion of no data among all eleven ecozones. This points to the relatively low-level of management that takes place in these communities, and its small size on the Nantahala and Pisgah landscape.

Figure 110. Nantahala & Pisgah FSVeg forest type breakdown within the floodplain forest ecozone.



Composition

Canopy composition is varied but often includes sycamore (*Platanus occidentalis*), tulip poplar, white ash (*Fraxinus americana*), black and yellow birch, eastern hemlock, and white pine. Musclewood (*Carpinus caroliniana*) is often present as a small tree in the subcanopy. While both types can have dense shrub layers consisting of doghobble and great laurel throughout, the river banks are covered with black alder (*Alnus serrulata*), yellowwood (*Xanthorhiza simplicissima*), Virginia sweetspire (*Itea virginiana*), and silky dogwood (*Cornus amomum*). Shrub density with greater than 50% cover occurs across 42% of national forest lands.

Examples of the two subtypes have a rich herb strata, typically with many annuals and biennials. Herbaceous species composition varies from site to site, and herbaceous strata can be quite patchy on the rocky substrate. The herbaceous layer is dominated by many rich cove mesic-loving species that are floodplain adaptive. Some more unusual native species include common white snakeroot (*Ageratina altissima var altissima*), false-nettle (*Boehmeria cylindracea*), river oats (*Chasmanthium latifolium*), and riverbank wild rye (*Elymus riparius*). Non-native herbs, particularly Japanese stilt grass, are typically prominent. Vascular plant counts have varied from 13 to 123 across sites within this ecozone. Low diversity sites were dominated by evergreen shrubs.

Connectedness

This habitat is very limited across the Nantahala and Pisgah NFs, and is often found to be fragmented on public and private lands due to past use. Today, various towns, cities, or reservoirs inhabit portions of the montane alluvial forest zone. Habitat of the large subtype within this zone is generally restricted across the Nantahala and Pisgah NFs to stretches of the Catawba, Nolichucky, French Broad, Davidson, Cheoah, Nantahala, and Hiawassee Rivers, as well as Upper, Curtis, and Shuler Creeks. The small river subtype is more evenly distributed, but also fragmented. Both subtypes are typically adjacent to acidic cove forest or grade into the shortleaf pine forest zone on upland slopes. Patch sizes of this habitat are variable and can be narrow in width. Contiguous patches do not exceed 30 acres, though a few are up to 50 acres in size. No obligate plant species are known for this habitat and while plant populations within this habitat can be fragmented, periodic flooding can result in long-distance dispersal and provide opportunities for genetic interchange.

Designated Areas

Less than 16% of this ecozone is currently within existing designated areas. The portion within the designated areas is primarily restricted to the Grandfather Ranger District.

Disturbance Dynamics

Openings are generally restricted to single trees and small groups and are generally not affected by flooding, though they can be impacted greatly by beaver activity. Large winds from major hurricanes can result in larger gaps, these occurring on a 20-plus year frequency (Batista and Platt 2003). In sites with dead or dying eastern hemlocks the gaps can be larger. Flooding typically does not affect the overstory, rather opens up sites with denser shrub layers, depositing sediments and nutrients and transporting plant propagules.

Fire is occurs infrequently in this ecozone, with a fire return frequency of surface fires unknown and speculated to range from 120 to 200 years (Landfire 2009). While prescribed burns are not prescribed for this ecozone, some portions do lie within larger burn units and serve as natural fire breaks for mostly shortleaf pine ecozone targeted burns. In the past seven years, prescribed burns have occurred across 140 acres within the floodplain forest ecozone of the Nantahala and Pisgah NFs. This represents 5% of the ecozone.

Nonnative Invasive Plant Species

In comparison with other ecozones, more invasive nonnative plant species have been located within floodplain forests, even those with fewer disturbances during the last 50 years (Carolina Vegetation Survey 2013). This invasion is most prevalent within the two subtypes that have an open shrub layer. Up to 23% of nonnative invasive plant species have been recorded within the less disturbed plots. All of the most invasive plant species have been recorded within this ecozone although the abundance of any single species varies.

Floodplain Terrestrial Wildlife

Riparian associated terrestrial wildlife species are incorporated into the mesic oak ecozone section above.

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Appendix A – R8 BIRD Survey Results – Nantahala and Pisgah National Forests 1997 through 2012

Species	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Total
ACADIAN FLYCATCHER	15	30	26	22	26	16	27	27	27	19	32	41	21	28	48	33	438
ALDER FLYCATCHER								7	2	6	15	12	15	4	13	15	89
AMERICAN COOT					2	4	1								1		8
AMERICAN CROW	115	100	141	130	132	137	106	136	143	91	105	90	70	143	160	117	1916
AMERICAN GOLDFINCH	55	40	59	78	41	69	38	19	47	40	57	52	41	27	26	13	702
AMERICAN REDSTART	2	5	2	2	2	1		2	1	1	6	6	1	8	4	4	47
AMERICAN ROBIN	58	69	55	69	69	39	39	58	93	82	90	82	67	81	110	106	1167
BACHMAN`S WARBLER				1	1												2
BANK SWALLOW		6															6
BARN OWL											1			1			2
BARN SWALLOW	4		1								1	2			1		9
BARRED OWL	1	5	2	3	2	1	1	3	2		8	2	1	1	1		33
BAY BREASTED WARBLER													3				3
BELTED KINGFISHER				1	1				2			1		1			6
BLACK-AND-WHITE WARBLER	36	46	37	59	57	42	31	54	60	33	41	35	44	58	55	65	753
BLACK-BILLED CUCKOO									1				1		1		3
BLACK-CAPPED CHICKADEE					3	2	6	8	7	3		11	7		2		49
BLACK-THROATED BLUE WARBLER	86	104	105	121	139	68	55	67	61	47	82	70	47	88	115	86	1341
BLACK-THROATED GREEN WARBLER	90	93	98	104	110	73	68	93	94	96	82	92	106	117	121	93	1530
BLACKBURNIAN WARBLER	16	34	34	34	31	14	12	30	19	19	22	22	14	22	20	19	362
BLUE GROSBEAK											2	1	2		1	3	9
BLUE JAY	60	59	43	73	59	36	35	47	61	33	54	46	37	58	60	70	831
BLUE-GRAY GNATCATCHER	11	7		7	8	4	6	3	2	10	9	15	7	9	3	6	107
BLUE-HEADED VIREO	128	140	170	133	158	65	35	64	74	47	88	74	61	98	83	82	1500
BLUE-WINGED WARBLER	43	42	36	11	6	9	3	4	1	6	2	2					165
BOAT-TAILED GRACKLE											1						1

Species	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Total
BROAD-WINGED HAWK	2	1	4	1	2	1	1	2	1		4	4		6	4	7	40
BROWN CREEPER	19	34	27	14	31	1	2	7	8	8	6	4	4	10	9	3	187
BROWN THRASHER	5	4	9	13	2	2	2	6	5	5	9	6	3		14	3	88
BROWN-HEADED COWBIRD	3	1	2	1	3				1		2	3	3	1	1	2	23
CANADA GOOSE			1		1	3	1	1	1				1	8	6	1	24
CANADA WARBLER	39	51	55	38	44	12	18	45	35	27	43	41	33	62	63	60	666
CAROLINA CHICKADEE	30	30	46	45	39	35	29	39	44	37	64	57	40	74	79	103	791
CAROLINA WREN	46	30	50	25	30	22	31	33	44	20	37	18	15	28	25	27	481
CEDAR WAXWING	40	25	19	5	26	6	7	18	16	16	8	37	3	17	13	19	275
CERULEAN WARBLER			1		1												2
CHESTNUT-SIDED WARBLER	238	297	270	326	338	200	141	123	145	91	92	80	88	68	83	81	2661
CHIMNEY SWIFT	10	22	15	13	10	8	3	7	17	9	10	15	7	13	4	10	173
CHIPPING SPARROW	13	4	10	7	1			4	1	1	4	3	3	9	3	2	65
COMMON GRACKLE	6	3	2	4		1					1	24	1		1	1	44
COMMON RAVEN	9	13	21	9	14	1	1	8	6	8	3	2		4	4	2	105
COMMON YELLOWTHROAT	39	30	32	41	44	38	43	38	39	43	32	29	34	24	28	17	551
COOPER`S HAWK		1									1	1					3
CRESTED CARACARA							1										1
DARK-EYED JUNCO	231	241	316	297	285	100	88	135	159	144	141	123	119	153	162	153	2847
DOUBLE-CRESTED CORMORANT				1													1
DOWNY WOODPECKER	15	12	14	15	6	3	2	6	8	7	10	10	8	5	20	21	162
EASTERN BLUEBIRD	4	5				2		4	3	1	4	2		4	1		30
EASTERN KINGBIRD												1		2			3
EASTERN PHOEBE	2	1	2	3		4	1	3	6	2	4	5	6	7	3	4	53
EASTERN SCREECH-OWL	1		1														2
EASTERN TOWHEE	267	224	237	237	207	198	173	182	192	136	194	164	152	130	126	143	2962
EASTERN TUFTED TITMOUSE	110	120	92	126	104	81	67	97	93	49	104	105	49	122	128	142	1589
EASTERN WOOD-PEWEE	22	21	19	22	31	4	3	4	15	8	14	15	17	17	12	16	240

Species	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Total
EUROPEAN STARLING		1															1
FIELD SPARROW	17	19	15	14	25	6	14	17	15	11	7	4	10	9	15	11	209
GOLDEN-CROWNED KINGLET	96	169	160	129	112	34	43	85	69	81	42	28	25	38	40	22	1173
GOLDEN-WINGED WARBLER	14	17	17	11	5	2	1	1	1		7		2				78
GRASSHOPPER SPARROW								1									1
GRAY CATBIRD	45	38	50	61	58	38	39	38	44	35	39	37	26	41	48	48	685
GREAT BLUE HERON											1						1
GREAT CRESTED FLYCATCHER	12	7	4	1	2		3	6	3		9	3	6	7	8	5	76
GREAT HORNED OWL			1					1									2
HAIRY WOODPECKER	18	11	10	6	13	4	5	6	7	9	9	7	5	13	4	11	138
HERMIT THRUSH	1	10		3	4			10	10	15	5	2	5	9	14	5	93
HOODED WARBLER	104	126	107	107	95	57	88	74	100	57	96	121	81	133	108	111	1565
HOUSE FINCH				1													1
HOUSE WREN			1								1	1			1	1	5
INDIGO BUNTING	158	189	182	164	166	125	117	110	110	76	105	98	47	88	99	92	1926
KENTUCKY WARBLER	10	2	5	7		3	3	3	3		5	1	1	2	2	1	48
LEAST FLYCATCHER	6	17	15	15	13	5	3	4	7	15	5	6	4	7	8	15	145
LOUISIANA WATERTHRUSH									1	2	6	3	5	7	5	5	34
MAGNOLIA WARBLER									4	1				1	1	2	9
MALLARD											1						1
MOURNING DOVE	18	23	30	23	21	21	9	36	15	7	31	24	14	16	18	30	336
NORTHERN BOBWHITE	3	4	9	3	6	2		1	4		1				4		37
NORTHERN CARDINAL	25	27	29	45	44	32	27	51	43	26	34	32	27	44	71	50	607
NORTHERN FLICKER	8	10	5	4	7	7	2	9	6	3	12	4	5	5	14	14	115
NORTHERN MOCKINGBIRD		1	1	1													3
NORTHERN PARULA	44	55	58	51	32	42	34	32	32	21	40	36	20	37	40	75	649
NORTHERN ROUGH-WINGED SWALLOW	2							2				2					6
NORTHERN WATERTHRUSH													2			1	3

Species	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Total
OVENBIRD	149	162	163	189	207	117	136	140	138	94	152	163	125	184	174	180	2473
PALM WARBLER								2	2								4
PEREGRINE FALCON					1		1									1	3
PILEATED WOODPECKER	79	63	59	84	71	65	54	67	85	48	48	39	45	72	63	71	1013
PINE SISKIN	16	23	10	8	32			8	9	7	12	20	12	33	10	3	203
PINE WARBLER	1	4	9	5	10	5	16	4	6	10	17	29	7	18	22	17	180
PRAIRIE WARBLER	6	9	6	17	17	13	9	4	3	1	1	7	1	10	7	10	121
RED CROSSBILL	1	4			8			16	7	8					2		46
RED-BELLIED WOODPECKER	8	10	7	12	6	4	12	7	6		13	10	7	17	19	18	156
RED-BREASTED NUTHATCH	21	27	25	24	21	2	7	19	29	21	31	26	40	50	46	44	433
RED-EYED VIREO	287	317	272	303	326	238	252	234	248	156	207	194	148	214	240	226	3862
RED-HEADED WOODPECKER	2										2	3			2		9
RED-SHOULDERED HAWK						1	1					1			3	1	7
RED-TAILED HAWK	6	3		2				1	2	1		1	1	1	3	1	22
RED-WINGED BLACKBIRD															4		4
REDDISH EGRET												1					1
ROSE-BREASTED GROSBEAK	46	55	57	52	39	51	28	29	31	5	31	29	22	36	22	29	562
RUBY-CROWNED KINGLET	6		4	5	8					1	1						25
RUBY-THROATED HUMMINGBIRD	5	5	7	8	7	2	3	6	10	3	7	4	5		5	3	80
RUFFED GROUSE	2	6	4	7	3	1	1	2	3		5	5	2	3	3	1	48
SCARLET TANAGER	93	106	77	84	90	56	66	67	59	58	63	57	47	75	84	102	1184
SHARP-SHINNED HAWK			1	1					1		1						4
SONG SPARROW	30	35	34	49	17	38	23	40	52	49	33	36	33	25	24	25	543
SUMMER TANAGER		1					1									1	3
SWAINSON`S THRUSH														1		7	8
SWAINSON`S WARBLER		2	2			2	1	1			1	2	2	3	7	8	31
TREE SWALLOW		2	1	1	1		1										6
TURKEY VULTURE	2		1	1	3	1	2				3		1		2		16

Species	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Total
VEERY	108	103	80	87	128	70	56	110	61	51	96	76	72	121	151	117	1487
VESPER SPARROW	1	1	2	2	5									1	1		13
WHIP-POOR-WILL	2			2	1			2						1		2	10
WHITE-BREASTED NUTHATCH	38	24	36	29	41	22	22	19	30	13	26	27	16	14	19	20	396
WHITE-EYED VIREO		1		4		1	2	2	1		4	3		7	3	5	33
WHITE-THROATED SPARROW	1			1							1						3
WILD TURKEY	1	3	12	5	8	2	2	3	3	1	11	9	7	3	9	19	98
WILLOW FLYCATCHER	4	4	3	2		3			19	1							36
WINTER WREN	84	103	140	123	104	10	7	33	48	35	32	34	23	29	22	24	851
WOOD THRUSH	39	37	32	57	28	40	28	39	47	16	43	46	27	61	41	76	657
WORM-EATING WARBLER	21	24	22	16	19	20	18	19	19	28	35	35	28	42	43	54	443
YELLOW WARBLER	11			3	2		4	3	6	2		1					32
YELLOW-BELLIED SAPSUCKER		3					2						1	4			10
YELLOW-BILLED CUCKOO		2	1	1	1	5	3	4	7	3	16	17	2	19	26	10	117
YELLOW-BREASTED CHAT	17	11	9	13	6	11	8	6	11	1	18	9		3	4	10	137
YELLOW-RUMPED WARBLER		1							5				1				7
YELLOW-THROATED VIREO	11	1	9	9	3	3	5	6	3	2	3	2	1	8	1		67
YELLOW-THROATED WARBLER	10	3	16	13	6	2	8	10	9	4	11	2		1	8	7	110
Totals	**3,560**	**3,831**	**3,854**	**3,956**	**3,888**	**2,465**	**2,244**	**2,774**	**2,970**	**2,123**	**2,874**	**2,705**	**2,092**	**3,021**	**3,184**	**3,120**	**48661**
total species richness	**86**	**88**	**85**	**89**	**84**	**77**	**79**	**85**	**88**	**73**	**93**	**91**	**80**	**82**	**91**	**83**	
number of points sampled	**239**	**251**	**245**	**246**	**245**	**202**	**201**	**245**	**240**	**166**	**252**	**252**	**186**	**254**	**253**	**253**	
relative species richness	**0.36**	**0.35**	**0.35**	**0.36**	**0.34**	**0.38**	**0.39**	**0.35**	**0.37**	**0.44**	**0.37**	**0.36**	**0.43**	**0.32**	**0.36**	**0.33**	