Spruce-Fir Forest Ecological Zone

Information presented in this draft report is considered under development. It may be incomplete and is likely unedited. This may make some sections difficult to follow. An updated version of this report will be posted when it becomes available.

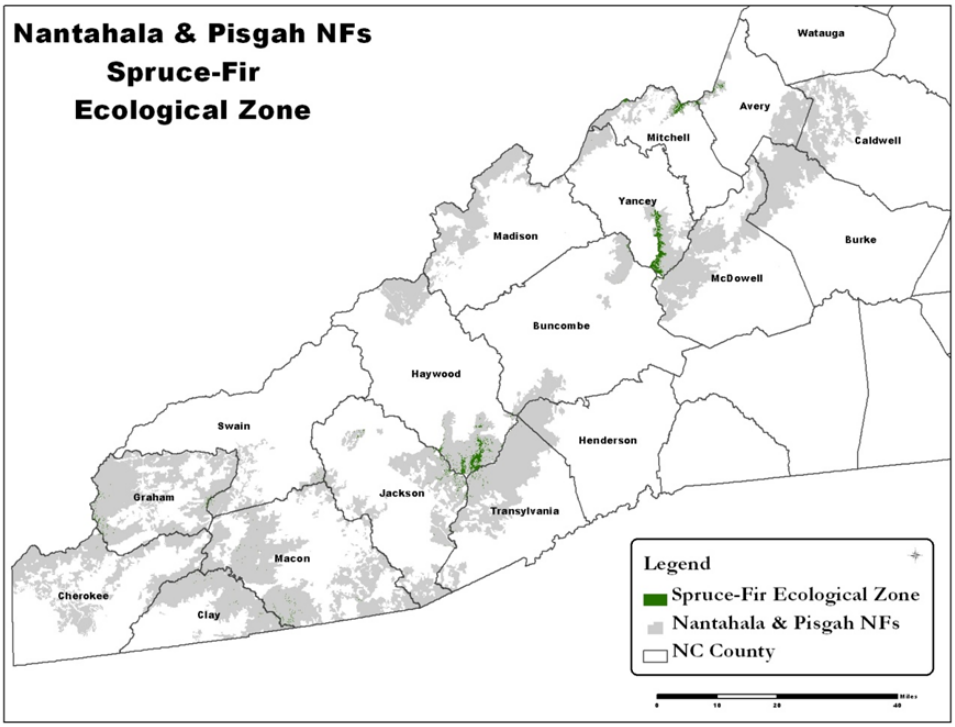
Environmental Setting: This ecological zone occurs at the highest elevations at all exposures and topographic positions from 5,200 to over 6,000 feet in elevation. In general, the zone occurs on exposed landforms that are convex in shape (Simon 2012). Moisture content is not limiting and is present both 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).

As long as 18,000 years ago spruce-fir dominated forests occurred in the southern Appalachians and have 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). Across the Nantahala and Pisgah NFs, the zone covers approximately 16,600 acres in six areas(Figure 1), (Smith and Nichols 1999). These six refuges contain the community assemblages in their least altered condition on the Nantahala and Pisgah NFs. The ecozone is more common in the Pisgah NF, primarily occurring at Roan Mountain and 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 wooly adelgid), and future 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 represented as a non-forest community (i.e. Graveyard fields in Haywood County, Newell and Peet, 1996).

Figure 1 Distribution of Spruce –Fir Ecological Zones across the Nantahala and Pisgah National Forests.



Composition: This ecozone is dominated by Fraser fir (*Abies fraseri*) or 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 mortality of canopy trees by Balsam woolly adelgid, former Fraser fir dominated forests are less abundant and have been replaced with red spruce. The shrub layer can be sparse to extremely dense, with Catawba Rhododendron (*Rhododendron catawbiense*) or occasionally Carolina Rhododendron (*Rhododendron caroliniensis*) or Great Laurel (*Rhododendron maximum*). 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*), (*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, four subtypes occur across the forest; an herb dominated one, a Rhododendron dominated type, a boulderfield type, a birch transition herb type, and a Rhododendron maximum type occurring at the lowermost extent of the zone (Natureserve 2013, Schafale 2012).

Federally Listed Species:

Many rare species occur within this high elevation zone. The rarest plant is rock gnome lichen (*Gymnoderma lineare*). While this species occurs within adjacent high elevation ecozones, spruce-fir habitat contains some of the highest quality populations. Few long-term monitoring plots exist for this species within this ecozone. Data collected at one population on Roan Mountain found an increasing population size (> 50%) from 1996 to 2011.

Connectiveness: Spruce-fir forest occurs as fragmented patches across the Nantahala and Pisgah NFs and western NC. A separation of 30-40 aerial miles currently occurs between spruce-fir concentration in the Black and Craggy Mountains and the eastern edge of the Great Smoky Mountains and Balsam Mountains. Spruce-fir forest is 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 stress 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 - 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 (< 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, Beck 1990, Blum 1990, Busing et al. 1993, Nicholas and Zedaker 1989, Collins et al. 2010).

Historic disturbances for the spruce-fir ecozone are related to the elevation and topographic conditions where it is found in on 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 (Dull et al 1998, Nicholas and Zedaker 1989). 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 that it grows on (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 an 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).

Regardless of the frequencies of these disturbances, they tend to occur at relatively small scales. Busing and Wu (1990) found low evidence of large-scale disturbance in old-growth spruce stands. After disturbance, red spruce and Fraser fir both respond favorably to release after many years of suppression resulting in rapid changes in the height of the remaining canopy after disturbance. However, 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, and height) and the influence of disturbances (balsam woolly adelgid, wind, ice, acidic deposition, historic logging and fire). Lidar analysis indicated that roughly 1%had a canopy height absent from it (Table 1). Three percent of the zone contains canopy heights less than five feet. Some of these areas likely include heath balds. Seven percent of the zone 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 representing forest height growth on some of the poorest, most exposed sites in the southern Appalachians. Forests with canopy heights ranging from 16 to 45 feet cover about 39% of the zone. Mature forest (36 to 75 feet) covers 54% of the delineated zone.. Eleven percent of the spruce-fir ecozone is greater than 75 feet in height. This height class includes both of 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 that either red spruce or Fraser fir.

Table 1: Spruce-Fir Ecozone Canopy Height Classes (Lidar Derived)

Height Class (Feet)	Acres in Height Class	Percent 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
Total	16,706	100

Table 2: Lidar Derived Shrub Density Class for the Spruce-Fir Ecozone

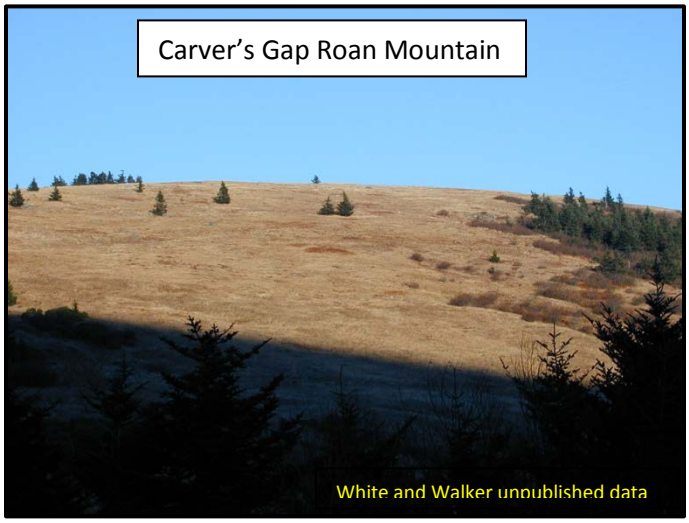
Shrub Density Class	Acres	Percent
Class 1 open	2,990	18.0
Class 2, 40-70%	6,419	38.7
Class 3, > 70%	7,171	43.3
Total	16,580	

Table 3: Lidar Derived Percent Cover for the Spruce-Fir Ecozone		
Percent Cover	Acres	Percent
0%	942	5.6
1-10%	470	2.8
11-25%	645	3.8
26-55%	1,727	10.2
56-75	2,487	14.7
76-100	10,620	62.9
Total	16,891	

After only light to moderate disturbance, Fraser fir and red spruce, due to their shade tolerance, develop ample advance regeneration, creating dense thickets with high degrees of vertical diversity (Brusing et al. 1992, Lusk et al. 2010, Colllins 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 area is open, which includes some embedded grassy balds habitat 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 4% of this zone has gaps up to 25% cover. 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.

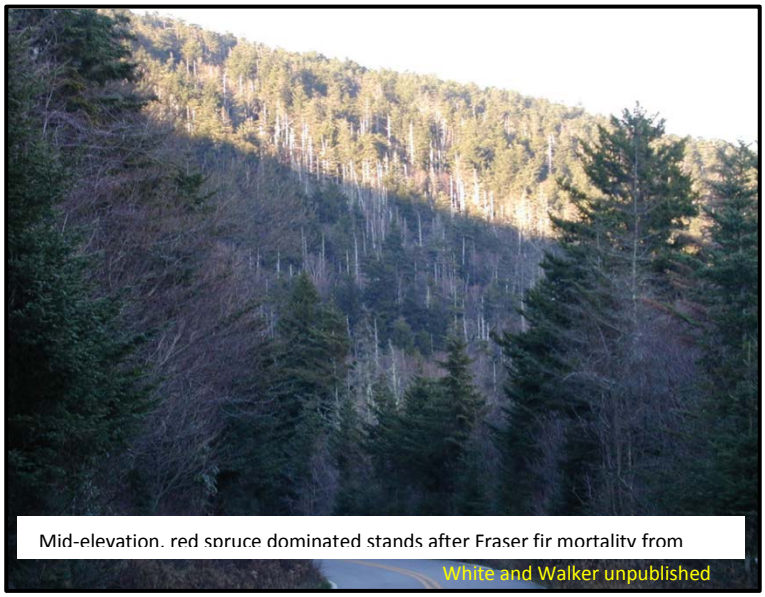
Where light reaches the lower levels of the community, shrub species such as hobblebush (*Viburnum alnifolium*) and smooth gooseberry (*Ribes rotundifolium*) promote dense understory conditions (Beck 1990, Blum 1990). Lidar analysis has identified current conditions within the ecozone containing high understory densities (Table 2). Forty-three percent of the existing vegetation has a closed shrub and sapling understory greater than 70%. Only 18% of the existing vegetation is open, with less than a 40% understory component. The degree of closed understory is consistent with the development of this system, the shade tolerance of its principle tree species, and the high levels of disturbance in the recent past from Balsam woolly adelgid.

The uneven-aged structure that was likely present in large portions of the pre-European settlement spruce-fire 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 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 Fir by the balsam woolly adelgid (BWA) (*Adelges picea*) (Dull et al. 1998, Smith and Nichloas 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



(Table 5) originated in 1952. These stands would have likely been immature during the initial wave of BWA infestation and not susceptible to infestation. Stand years of origin are episotic in the 1960's and 1970's when the Balsam woolly adelgid would have been operating with significant young forest habitat creation in 1965, 1967, 1973, and 1977.

The BWA associated mortality altered the structural composition of the spruce-fir ecozone dramatically from its condition of mature spruce forest. 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 BWA 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 BWA (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 have potential for increasing its importance at lower elevations and currently hardwood dominated sites within the Nantahala and Pisgah NFs where it once may have been more abundant (Morin and Widmann 2010, Nowacki et al. 2010, Busing et al. 1992, Oprean and Rodrigue, personal communication).



Mid-elevation, red spruce dominated stands after Fraser fir mortality from

Age Class

Table 5. Nantahala & Pisgah National Forests Spruce/Fir Ecozone Current Silvicultural Age Class Distribution

Silvicultural	Closed	Open	Total
Age Class	Acres (%)	Acres (%)	(%)
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
Total	16,604		100

Current Silvicultural Age Class Distribution

Early age classes are essentially absent over 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 the era of exploitive logging within the spruce-fir ecozone (Brown 1941 need citation, 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 the higher level of harvesting that occurred prior to the development of the original forest plan in 1986. 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 6.Nantahala & Pisgah National Forests 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
Total	All	16,604	100

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

Figure 2

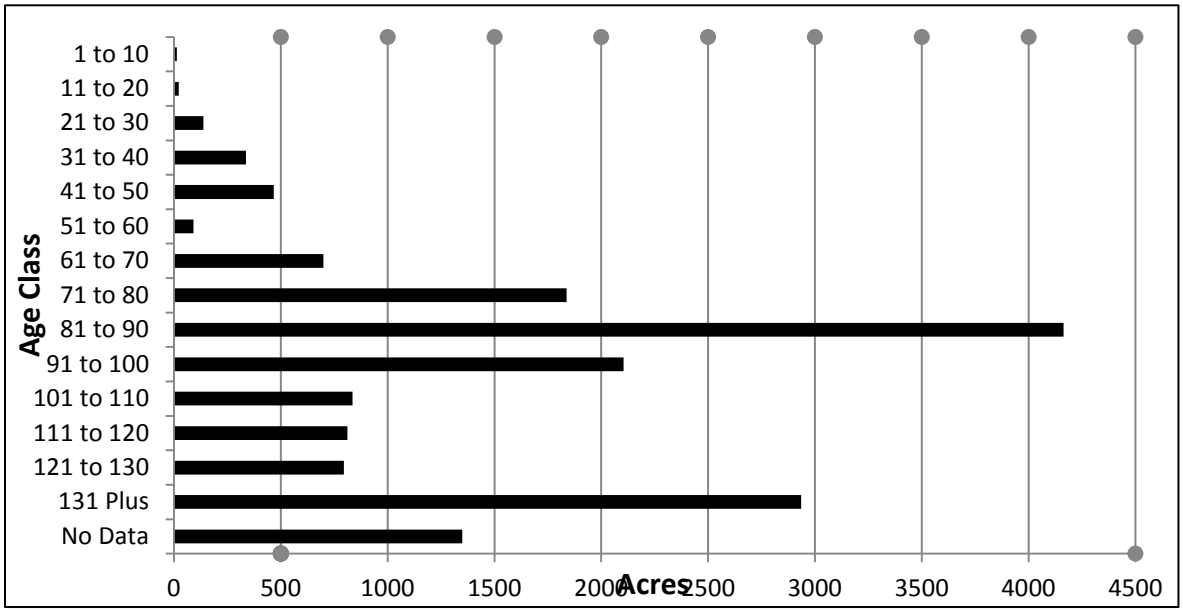
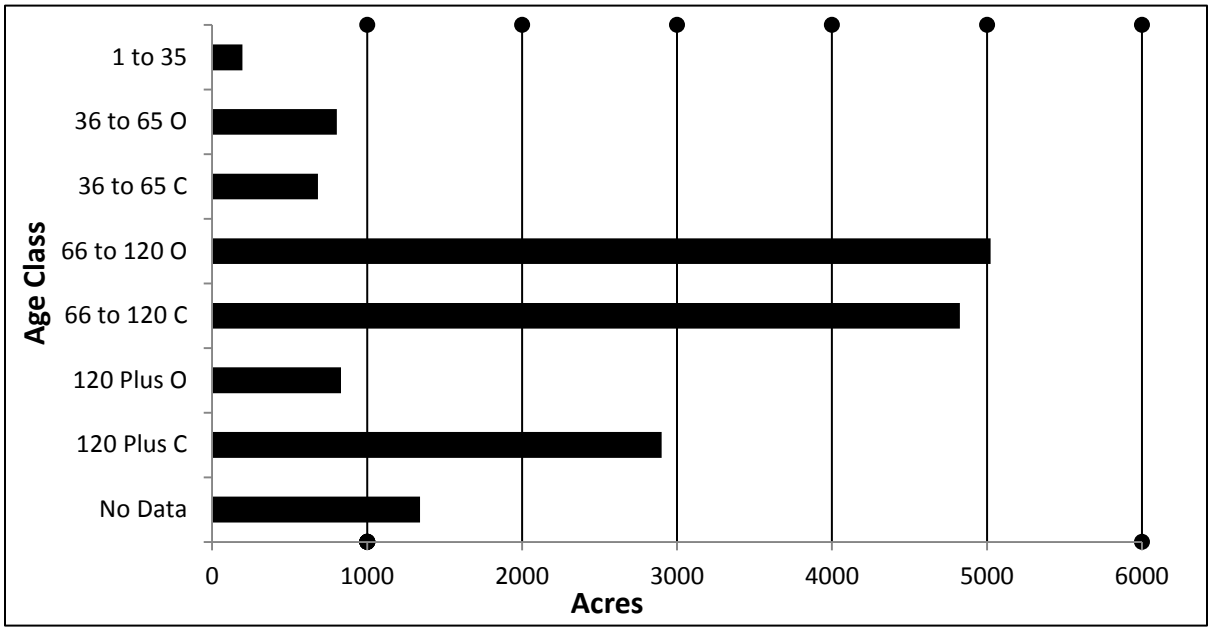


Figure 3



<u>HRV Current Age Class Distribution</u>

The 66 to 120 year-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 mid and young forest conditions, with around 1% as young forest habitat. The open habitats are more numerous in the mid and late age classes with in this ecozone as they likely recover from the impact of BWA. The converse is true of the old growth age class, which is dominated by the closed condition.

Threats and Stressors

Table 7. 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 (Barnard and Lucier 1991, Blum 1990).

[€] Climate Change leading to higher average annual temperatures may be a benefit to BWA (Balch 1952 need citation)

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

Terrestrial Wildlife Component

Spruce-fir habitats in North Carolina provide critical breeding habitat for many rare birds, many of which are likely endemic to high peaks (Pashley et al. 2000, Rich et al. 2004, Johns 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) identities 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 wooly 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 at least are 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 identities that 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*), are of conservation priority. 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). However, canopy species such as blackburnian and black-throated green warblers seem to be declining.

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

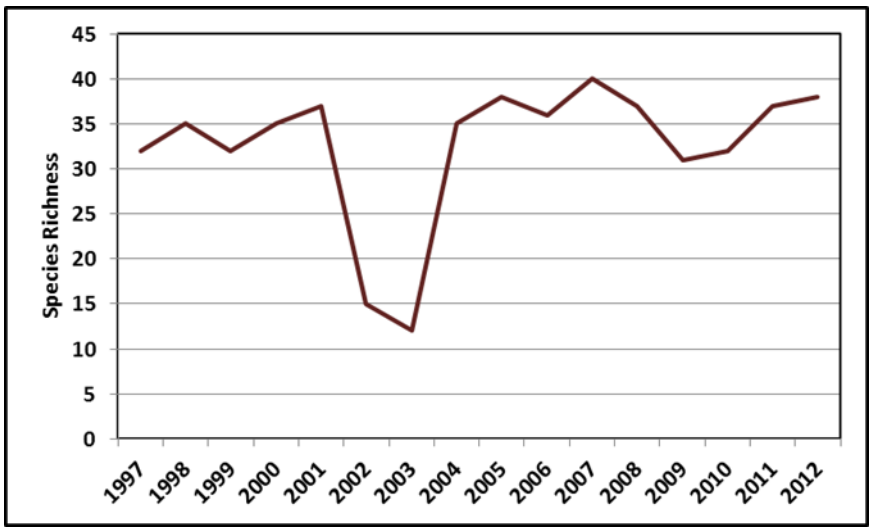
most susceptible to extirpation from habitat deterioration and the least likely species to become reestablished in areas that have recovered (Rabenold et al. 1998). Because spruce-fir habitats are vulnerable to the stresses of the balsam woolly adelgid and climate change, these species are particularly 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, R8Bird 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 4).

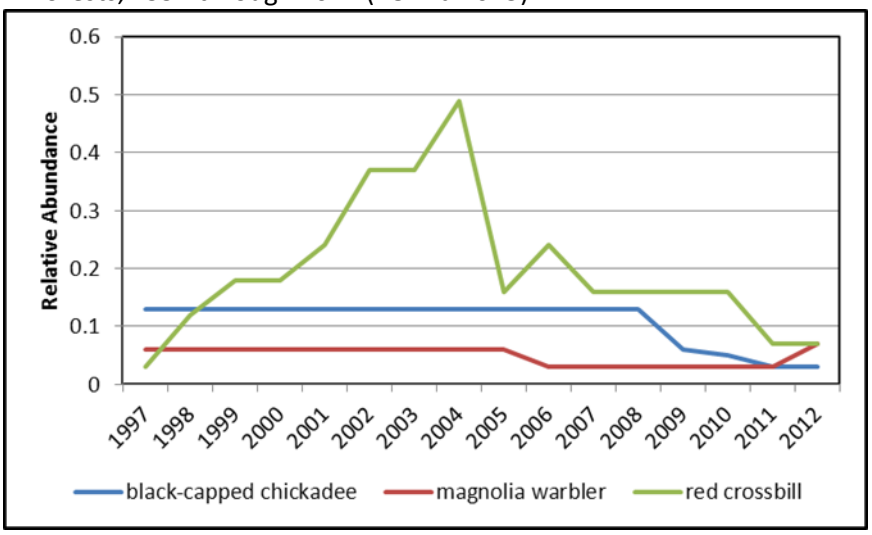
Figure 4. Landbird species richness within spruce-fir forests on the Nantahala and Pisgah National Forests, 1997-2012 (R8Bird 2013).



Long-term monitoring data (R8Bird 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 extremely 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*.

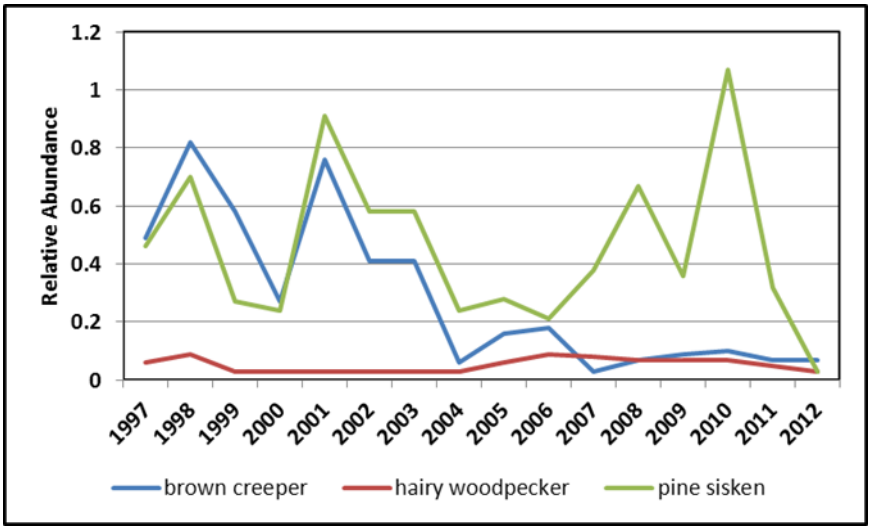
Population trends of magnolia warblers and black-capped chickadees are stable to slightly declining within spruce-fir habitats. Red crossbill populations are also decreasing, have exhibited higher variability over the sixteen-year monitoring period (Figure 5).

Figure 5. Relative abundance of bird species that occur at naturally-low densities associated with spruce-fir forests, 1997 through 2012 (R8Bird 2013).



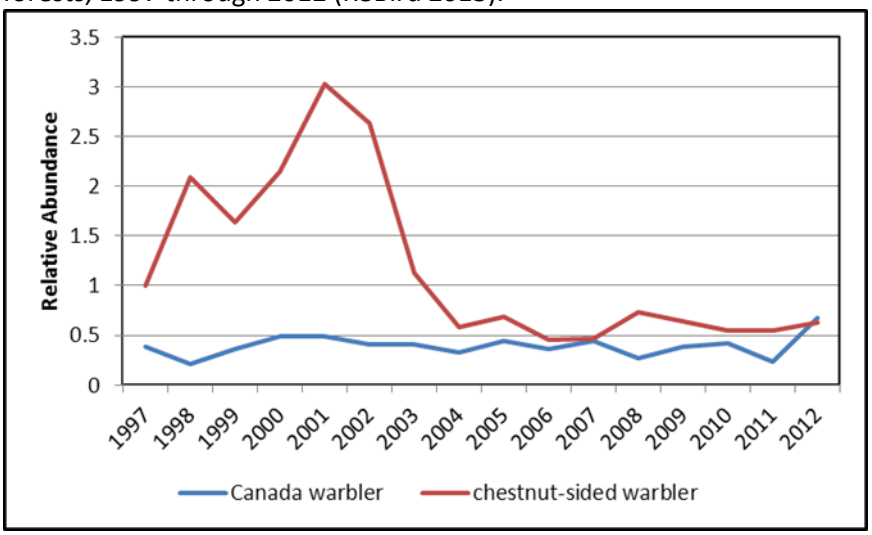
Additionally, long-term monitoring data (R8Bird 2013) includes three NCWAP priority bird species associated with spruce-fir forests that occur at moderate densities. These species include the hairy woodpecker (*Picoides villosus*), brown creeper, and pine sisken (*Carduelis pinus*). Population trends of hairy woodpecker and pine sisken 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 6).

Figure 6. Relative abundance of bird species that occur at moderate densities associated with spruce-fir forests, 1997 through 2012 (R8Bird 2013).



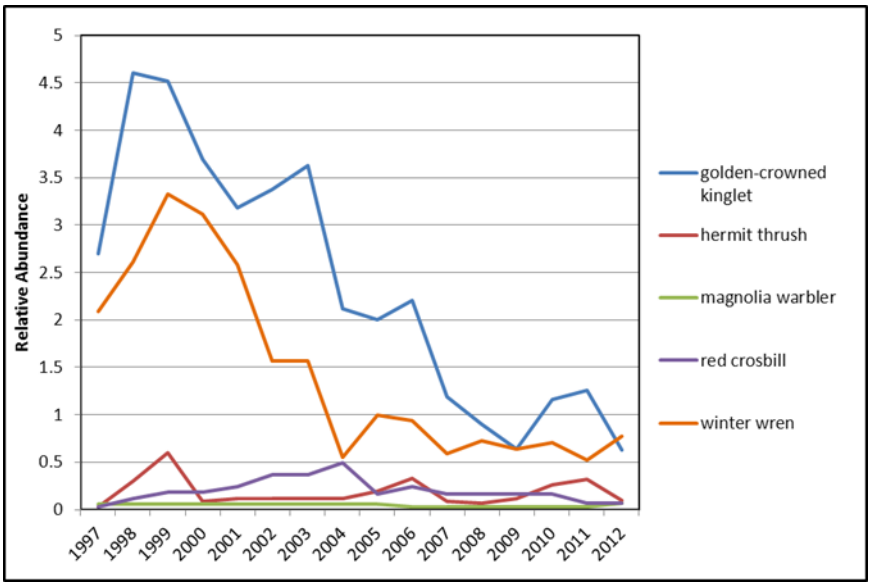
Long-term monitoring data (R8Bird 2013) includes two NCWAP priority bird species associated with spruce-fir forests that occur at higher densities. These species include the Canada warbler and chestnut-sided warbler. Population trends of Canada warblers have been stable to slightly increasing within spruce-fir habitats over the sixteen-year monitoring period, while chestnut-sided warbler populations appear to have decreased substantially since 1997 (Figure 7). This decrease is likely due to the loss of early successional habitat characteristics at high elevations, including spruce-fir, forests.

Figure 7. Relative abundance of bird species that occur at higher densities associated with spruce-fir forests, 1997 through 2012 (R8Bird 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 8).

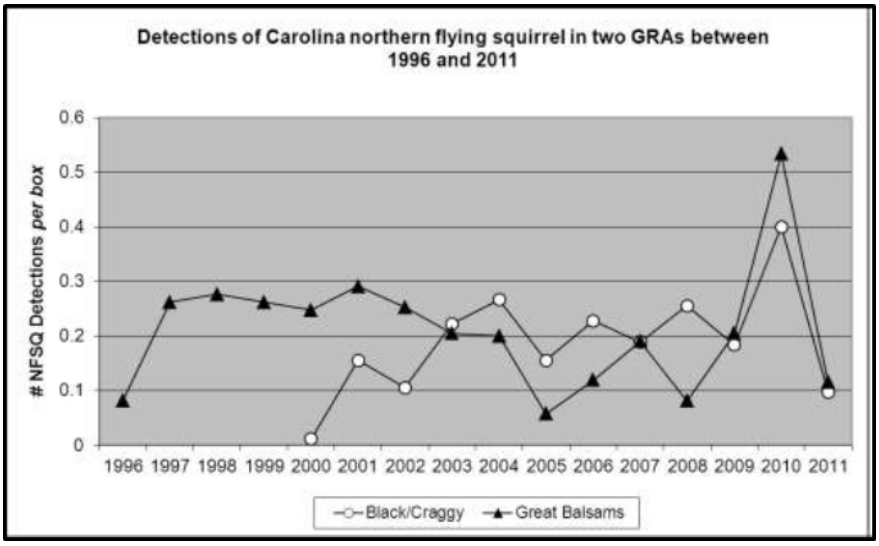
Figure 8. Relative abundance of bird species considered to be spruce-fir obligates, or near-obligates within spruce-fir forests, 1997 through 2012 (R8Bird 2013).



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. 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 9).

Figure 9. 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 includespruce-fir habitats.

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Appendix A – R8BIRD 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

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Species	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Total
BLUE-WINGED WARBLER	43	42	36	11	6	9	3	4	1	6	2	2					165
BOAT-TAILED GRACKLE											1						1
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

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Species	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Total
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
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	2							2				2					6

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Species	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Total
SWALLOW																	
NORTHERN WATERTHRUSH													2			1	3
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

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Species	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Total
TREE SWALLOW		2	1	1	1		1										6
TURKEY VULTURE	2		1	1	3	1	2				3		1		2		16
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
Total	**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**	

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