Range expansion and habitat selection in breeding populations of Red-breasted Nuthatch (*Sitta canadensis*) in the southeastern United States

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Abstract

The association of Red-breasted Nuthatch (*Sitta canadensis*) with spruce–fir forests in the Appalachian Mountains is well known; during the mid-twentieth century, however, the species was also found nesting and summering at lower elevations, primarily in association with hemlock forests. More recently, breeding populations have been found at still lower elevations in the Appalachian region; three southeastern states documented their first nesting records of the species between 1996 and 2003, mostly in mixed forests best described as white pine–hemlock–deciduous forests. In pre-twentieth-century literature, there are hints of the species' prior occurrence in such areas, and it may be that, after extensive logging in the early twentieth century, changes in habitat and forest maturity have begun to draw the species back to former range. It is also possible that the introduction of pathogens such as the Balsam Woolly Adelgid may have contributed to shifting Red-breasted Nuthatch populations out of higher-elevation spruce–fir forests and into lower-elevation areas. Forest conservation and preservation strategies must be considered if populations of this species are to thrive in the mountains of the southeastern United States.

Red-breasted Nuthatch, Rabun County, Georgia, 2 June 2004.

Introduction

Red-breasted Nuthatch (*Sitta canadensis*) is a permanent resident of the northern coniferous forests of North America, with a breeding range that extends southward in close association with spruce–fir forests of the higher elevations of the Appalachian Mountains in the southeastern United States. During the mid-twentieth century, Red-breasted Nuthatches were also found in summer within middle elevations, primarily in association with hemlock forests. In recent years, there have been multiple records documenting breeding of this species in lower-elevation areas of the Appalachian region. These include small, disjunct pockets of occurrence along the Cumberland Plateau in Kentucky and Tennessee, as well as more substantial populations along the Blue Ridge Escarpment in Georgia and South Carolina. There have also been multiple records of breeding range expansion into lower- and middle-elevation areas in the Allegheny Mountains of West Virginia and Virginia, in the Blue Ridge Mountains of Virginia, North Carolina, Tennessee, and Georgia, and indications of possible expansion into the Ridge and Valley section of Tennessee and Georgia.

Habitat preference for breeding Red-breasted Nuthatches in these lower-elevation areas tends towards white pine–hemlock–deciduous forests, which suggests that recent maturation of this forest type within these areas is a key factor in range expansion in this species. Recent degradation of the spruce–fir forests of the higher elevations, as well as the mid-twentieth-century decline of the American Chestnut (*Castanea dentata*), may have spurred the species' breeding range expansions into lower elevations. Outside the spruce–fir forests, the natural range of Eastern White Pine (*Pinus strobus*) may be the key factor delimiting the historic as well as the recently expanded range of Red-breasted Nuthatch within the southeastern United States. An understanding of the historic and current environmental factors driving these range and population changes will be important in determining an adequate plan for habitat management for the preservation of Red-breasted Nuthatch populations within the Appalachian region of the southeastern United States.

Breeding range of the Red-breasted Nuthatch in the southeastern United States in historic context

Up until the mid-twentieth century, the breeding range of Red-breasted Nuthatch in the southeastern United States was thought to be limited to spruce–fir forests within the higher elevations of the Appalachian Mountains and to extend no farther south than eastern Tennessee at Roane, Great Smoky, and Unicoi Mountains and in western North Carolina at Black Mountain and Mount Mitchell (A.O.U. 1957). A few earlier records from the late nineteenth and early twentieth centuries, however, hint that breeding outside of that range may have occurred. Most notable was one record for Oconee County, South Carolina on 10 June 1910 (Sprunt and Chamberlain 1949), the same location where nesting was verified in 2003 (Renfrow 2003). Very close to the area of recent range expansion was a late-spring record at Lake Rabun, Rabun County, Georgia 11 May 1947 (Burleigh 1958), although this record may pertain to a late-departing transient. There seems to have been no early evidence to indicate breeding of this species on the Cum-

berland Plateau, which is located along a line running approximately 150 km west and north of the spruce–fir forests of the Appalachians. A record of a female collected 16 July 1886 at Bardstown, Nelson County, Kentucky (elevation 198 m; Beckham 1886), some 140 km west of Kentucky's Cumberland Plateau population, may pertain to an isolated post-irruption summering individual or post-breeding transient. In North Carolina, Brewster (1886) found a presumed breeding pair in late May 1885 near Highlands, Macon County in old-growth hemlock forest at middle elevation (1219 m).

The first clear indications of a breeding population in the southern Appalachians outside of the spruce–fir forests came in the 1940s during several intensive field studies undertaken to census breeding bird populations in middle-elevation areas of eastern Tennessee and western North Carolina. In the Highlands area of North Carolina, Holt (1974) began a series of studies in 1946 in which this species was again found present in summer between 1160 and 1250 m. In the Great Smoky Mountains National Park, Kendeigh and Fawver (1981) conducted fieldwork during the summers of 1947 and 1948 and found this species in a broad range of elevations within study areas between 873 m and 1795 m elevation. Stupka (1963) denotes a record of a Red-breasted Nuthatch at 884 m at Cades Cove 12 June 1958 as constituting the lowest-elevation breeding season record for this species in the Great Smoky Mountains National Park.

It was not until the latter part of the twentieth century, however, that the breeding range of the species was found to extend into South Carolina and Georgia. On 26 May 1986, one of two Red-breasted Nuthatches sighted was observed inspecting cavities at the Chattooga Recreation Area (elevation 780 m) in Sumter National Forest, Oconee County, South Carolina (Post and Gauthreaux 1989; W. Post, pers. comm.). In the mid-1990s, summer records were obtained in Oconee County as well as on the other side of the Chattooga River within Chattahoochee National Forest in Rabun County, Georgia (Oberle and Forsythe 1995, Oberle and Haney 1997). In 2000, Red-breasted Nuthatches were found to be well distributed along the Chattooga River. In the 28 river-kilometers between Burrell's Ford (elevation 650 m) to the north and Earl's Ford (elevation 490 m) to the south (Figure 1), a total of 14 individuals were observed at 10 separate locations 12–15 June 2000. In May 2002, a first Georgia nest was photographed and documented at the Nicholson Tract of the Chattahoochee National Forest; two additional Rabun County nests were located in the vicinity during the 2002 breeding season. Another nest was located at the Nicholson Tract on 19 April 2005. In April 2003, a first South Carolina nest was photographed and documented at the Chattooga Recreation Area in Oconee County. A second South Carolina nest was found near Burrell's Ford in Oconee County on 15 April 2005 (Renfrow 2003, Renfrow, in press; Renfrow, unpubl. data).

Figure 1. Male Red-breasted Nuthatch in Oconee County, South Carolina, 14 June 2000.
All photographs and map graphics by the author.

There are indications that Red-breasted Nuthatch may nest in additional scattered locations within the Chattahoochee National Forest in northern Georgia, with two records for June 1996 at the Cooper Creek Scenic Area (734 m) in Union County and several records at Jack's River (330 m) in the Cohutta Wilderness Area in Fannin County for the summer of 2000. There are also summer records from 1995–2000 for Rabun County from one higher elevation location, Rabun Bald (1436 m) (Oberle and Haney 1997, Beaton et al. 2003; G. Beaton, pers. comm.). The species has been found in summer along Persimmon Ridge Road (608 m) in Greenville County, South Carolina (Carter 1993).

Nesting of Red-breasted Nuthatch on the Cumberland Plateau was not suspected until this species was observed at the Rock Bridge area (300–340 m) of the Red River Gorge Geological Area, Daniel Boone National Forest, Wolfe County, Kentucky during the summer of 1996. An inactive nest hole coated with pine resin was photographed at this location on 2 July, and an adult male was observed feeding recently fledged young on 4 July. Evidence of a very small population of three to six pairs was gathered here during subsequent breeding seasons encompassing 1997–2005. An active nest was photographed and documented at Rock Bridge in May 1999. Another Wolfe County nest record was obtained on 18 June 2005 along Parched Corn Creek, 5 km distant from Rock Bridge (Renfrow 1996, 1999a, 2001, Renfrow, unpubl. data).

Farther south along the Cumberland Plateau, a male Red-breasted Nuthatch was located on 26 May 2002 near Bandy Creek (400 m) at the Big South Fork National River and Recreation Area in Scott County, Tennessee. Subsequent attempts to relocate this species in the summer of 2002 were unsuccessful. On 7 June 2003, an active Red-breasted Nuthatch nest was observed and photographed in the same location as the 2002 sighting. Red-breasted Nuthatches were again observed exhibiting behavior indicative of breeding in the Bandy Creek vicinity on 7 and 11 July 2005 in two separate locations (Renfrow and Stedman 2003, Renfrow, unpubl. data).

In West Virginia, nesting was considered to be limited to the higher mountains and mountain valleys by Hall (1983); very few published records of breeding birds come from elevations below 900 m. West Virginia's Breeding Bird Atlas project also found this species limited to the higher areas of the Allegheny Mountains, with records from Tucker, Grant, Randolph, Pocahontas, Greenbrier, Webster, and Nicholas Counties (Buckelew and Hall 1994). In 1997, breeding Red-breasted Nuthatches were found to be well distributed at a lower-elevation site in Pocahontas County, with nesting confirmed at 850 m on 24 June (Renfrow, unpubl. data).

In Virginia, Kain (1987) described Red-breasted Nuthatch as a locally common summer resident at Mt. Rogers and a locally uncommon to rare summer resident elsewhere in the higher elevations. During the 1984–1989 Virginia Breeding Bird Atlas proj-

ect, breeding evidence was reported in Grayson, Highland, Wise, Rockbridge, Botetourt, and Augusta Counties, with breeding confirmed at Whitetop and Old Rag Mountains (R. Clapp, pers. comm.). In 2002, two lower-elevation nests were located in Montgomery County, the first at 634 m on 27 April and the second at 616 m on 2 June 2002 (R. Mays, unpubl. data). In May 2004, two additional nests were located in this same vicinity (R. Mays, pers. comm.). A Red-breasted Nuthatch at Big Black Mountain (1265 m) in Harlan County, Kentucky on 3 July 1982 (Palmer-Ball 2003) was most likely a wandering individual from the nearby Wise County, Virginia breeding population, as there is virtually no coniferous element on Kentucky's Big Black Mountain.

Figure 2. A white pine–hemlock–deciduous forest in Wolfe County, Kentucky. Note the dominance of Eastern White Pine.

This series of new breeding records in the southeastern United States roughly coincided with an earlier established trend towards southward range expansion of the species in other states just to the north. However, in contrast to the records from southern areas—documented in naturally regenerating mixed forests—the northern states' records have been documented primarily in maturing conifer plantings. In Pennsylvania, maturation of conifer plantations established during the 1930s provided habitat for nesting Red-breasted Nuthatches by the early 1960s. Expansion in Pennsylvania continued well into the 1990s, with first county nest records for Philadelphia County in 1995 and Allegheny County in 1996 (McWilliams and Brauning 2000; R. Leberman, pers. comm.). In southeastern Ohio, summering Red-breasted Nuthatches were observed intermittently during the 1980s (Peterjohn 1989), and nesting was confirmed in summer 1998. Further nesting evidence was gathered during the subsequent breeding seasons of 1999–2005, but only a total of one to three pairs could be located in any given year. Although a few native pine species do occur in Hocking County in mixed association and although hemlock–deciduous forest is found in several deep gorges, the Red-breasted Nuthatches here were only found in areas of planted pines (Renfrow 1998, 1999b, 2002, Renfrow, unpubl. data).

Figure 3. An adelgid-killed old-growth Eastern Hemlock at Shenandoah National Park, Madison County, Virginia, 17 April 2004.

Distinct from these recently established Red-breasted Nuthatch breeding populations are isolated breeding occurrences outside of the main breeding range, often following major winter irruptions (Peterjohn 1989, Ghalambor and Martin 1999). These post-irruptive breeding records may be located within urban and suburban areas among plantings of ornamental conifers. Examples include a nesting at a cemetery in Hamilton County, Ohio in 1982 and a nesting attempt at a Campbell County, Kentucky cemetery in 2001 (Renfrow 1982, 2001). A June 1973 Knoxville County record of recently fledged young at 300 m, constituting the first confirmation of breeding in Tennessee outside the Unicoi Mountains (Owen 1979), and a June 1975 record of recently fledged young at Rockingham County, constituting the only breeding record for North Carolina's piedmont (Burroughs 1976), occurred subsequent to minor winter irruptions in association with bird feeders in wooded residential areas with pines.

Harrap and Quinn (1995) describe some variability of the southern boundary of the breeding range of Red-breasted Nuthatch in the Appalachians, with greater numbers breeding on the southern periphery in years following good cone crops. This is also indicated by Mays (unpubl. data) in reference to the breeding population in Montgomery County, Virginia, which does not seem to be present on an annual basis. Assumptions of sporadic occurrence may on occasion be incorrect, as breeding Red-breasted Nuthatches can easily be overlooked. Peterjohn (1989) described summering Red-breasted Nuthatches at Hocking County, Ohio as remaining for only one or two years and then disappearing. Intensive scrutiny of the planted pine areas in Hocking County has since revealed consistent nesting activity 1998–2005 (Renfrow 1998, 1999b, 2002, Renfrow, unpubl. data). These birds are often present at one isolated pine stand in one year and at another stand the next year, so all suitable habitat must be thoroughly covered to assess annual occurrence accurately. Inaccessibility of their habitats and secretive behavior during the breeding season may account for these populations being overlooked until the latter half of the twentieth century, as was the case with Swainson's Warbler (*Limnothlypis swainsonii*), which also breeds in some of the same areas (Renfrow and Stedman 2003). In North Carolina, Holt (1974) described the difficulties for field studies posed by impenetrable tangles of rhododendron in the virgin hemlocks, which she traversed with great effort on hands and knees. Along Ohio's Allegheny Plateau, Hicks (1935) emphasized the inconspicuousness and choice of secluded habitats as primary factors contributing to the extreme difficulty of locating Red-breasted Nuthatches during the breeding season.

Historic habitat changes

A possible shift or expansion of breeding populations of Red-breasted Nuthatch from the higher elevation spruce–fir forests into nearby lower-elevation white pine–hemlock–deciduous forests might have been caused by a variety of changes to the forests of the southern Appalachians wrought by anthropogenic factors such as logging and

clearing for subsistence agriculture and the subsequent regeneration of mixed forest. The introduction of pathogens resulted in a host of catastrophic tree diseases that adversely affected the higher-elevations forests in particular. Changes in the breeding range of Red-breasted Nuthatch may have resulted from the conflicting influences of expansion and recovery of Eastern White Pine in the lower-elevation forests coincident with the loss of spruce–fir habitat occurring in the higher elevations.

Land use practices in the Eastern United States during the nineteenth century eliminated Eastern Hemlock (*Tsuga canadensis*) and Eastern White Pine from many areas of the deciduous forest, particularly the northern hardwood and central broad-leaved regions. The use of hemlock bark by the tanning industry, along with logging and fires, severely restricted the distribution of both conifer species (Yahner 2000). In the southern Appalachians, the remoteness of the area delayed the destruction of the forests. Logging operations for Eastern White Pine started in 1875 on the North Carolina section of what was to become the Great Smoky Mountains National Park, where this pine species comprised 20 per cent of the bottomland forests (Stupka 1964). Fire was also a factor: for instance, Eastern White Pine was negatively affected by wildfires that consumed over 50,000 acres within Caldwell County, North Carolina in 1894 (Ashe 1895).

The first of a series of catastrophic tree diseases began in 1904 with the accidental introduction into North America of *Endothia parasitica*, the fungus responsible for chestnut blight. In the southern Appalachians, the American Chestnut once comprised an estimated 25 per cent of the mixed deciduous forest. By the 1940s, the chestnuts were almost entirely extirpated, leaving only the stubbornly regenerating sprouts still present today. Large openings created by the loss of the chestnuts resulted in the exposing of mineral soils particularly favorable to the regeneration of Eastern White Pine (Walker 1990, Yahner 2000). Loss of the American Chestnut has also been linked to an increase in Rosebay Rhododendron (*Rhododendron maximum*) and Mountain Laurel (*Kalmia latifolia*), now estimated to cover an estimated 2.5 million ha in the Appalachians. In turn, the dense cover of Rosebay Rhododendron has been linked to increased regeneration of Eastern Hemlock (George and Bazzaz 2003).

Many plots of land cleared for agricultural use by nineteenth century settlers in the Appalachians were abandoned during the agricultural depressions of the 1890s as well as during the Great Depression of the 1930s. These abandoned fields were quickly succeeded by stands of naturally regenerating Eastern White Pine, renewing the ecological cycle (Walker 1990). This is particularly evident in the areas where breeding Red-breasted Nuthatches reach their highest densities in northeastern Georgia, at the Nicholson tract of the Chattahoochee National Forest as well as in South Carolina's Sumter National Forest at the Russell Farmstead, located just across the Chattooga River from the old Nicholson farmstead (Renfrow 2002).

Figure 4. Eastern White Pine resin applied to Red-breasted Nuthatch nest entrance Oconee County, South Carolina, 2 June 2003.

Beginning in 1911, much of the land in the Chattooga River watershed was purchased by the U.S. Forest Service, resulting in a period of recovery and renewal for the region's forests (Boyd 2001). Despite the intervening period of settlement activity, there is a remarkable similarity between early accounts of the forest and the condition of the forest along the Blue Ridge Escarpment today. In a 1776 description of the habitat of the southern Blue Ridge Escarpment, William Bartram described the approach to "Occonne Mountain" as "a magnificent landscape infinitely varied" with a species of rhododendron "foremost in the assembly of mountain beauties"; after relating a series of steep rocky ascents, Bartram lists Eastern White Pine first in a roster of tree species present (Doren 1955). In this same area, over two hundred years later, Gaddy (2000) describes Eastern White Pine as one of the most commonly encountered evergreens on slopes that are often dominated by a shrub layer of heath species including three species of rhododendron.

A similar cycle of renewal has taken place on the Cumberland Plateau. Thomas (1926) described a vast forest of the finest white pine at Wolfe County, Kentucky just prior to the culmination of extensive logging of the area. These forests have now returned to Wolfe County, with the greatest densities of Eastern White Pine occurring in the Rock Bridge area (Figure 2). The historic White Pine Church (less than one km from the Scott County, Tennessee nest location) may predate the extensive logging operations of the early twentieth century (Manning 1993) and now stands within a maturing second-growth forest again dominated by Eastern White Pine (Renfrow and Stedman 2003).

During this period of recovery and possible expansion of the white pine–hemlock–deciduous forests in the lower elevation of the Appalachians, there was a precipitous decline in the health of the spruce–fir forests in the higher elevations. The Balsam Woolly Adelgid (*Adelges piceae*), inadvertently brought into North America at the beginning of the twentieth century, was found to have reached the endemic Fraser Fir (*Abies fraseri*) population of the southern Appalachians during the mid-1950s (Catlin 1984). During the latter half of the century, a majority of mature Fraser Firs succumbed to this adelgid. At Mount Collins in the Smokies, Fraser Fir has been virtually eliminated and canopy cover reduced to half of its previous level (Rabenold et al. 1998). The death of the firs caused weakening in the anchoring of the intertwined roots of adjacent Red Spruces (*Picea rubens*) (Gove 1996). Subsequent vulnerability to windstorms along with other possible factors, including drought, ice storms, and acid rain have resulted in the loss of nearly 50 per cent of the Red Spruce trees at high elevations from New England to North Carolina in the 1980s and 1990s (Ayers et al. 1998).

Further complicating this already complex series of catastrophic events affecting the Appalachian forests, the Hemlock Woolly Adelgid (*Adelges tsugae*) was imported into North America in the mid-twentieth century. During the 1990s, widespread death of hemlocks began to occur in the Shenandoah National Park (Figure 3), and evidence of this adelgid has since been found in the southern Appalachians, casting doubt on the long-term survival of Eastern

Hemlock in many areas (Ayers et al. 1998, LeGrand 2004). Hemlock mortality in the northeastern United States has been linked to declines in populations of Black-throated Green Warbler (*Dendroica virens*), Acadian Flycatcher (*Empidonax virescens*), and Blackburnian Warbler (*Dendroica fusca*) and an increase in some species birds not associated with conifers in the East, including White-breasted Nuthatch (*Sitta carolinensis*) (Tingley et al. 2002). In the same study, data on Red-breasted Nuthatch did not show significant trends (Tingley et al. 2002). There are indications that breeding Red-breasted Nuthatches in the lower-elevation areas may be successfully adapting to the loss of hemlock in areas where other conifers are present. In 2002, breeding was confirmed in Montgomery County, Virginia at 634 m in an area with Eastern White Pine listed first in order of abundance; in this vicinity, only a few declining, adelgid-infested hemlocks were present (Mays, unpubl. data). Red-breasted Nuthatches were also found in association with Eastern White Pine in areas with standing dead hemlocks in eastern Augusta County, Virginia in April 2004 (Renfrow, unpubl. data).

Habitat selection in Appalachian populations of Red-breasted Nuthatch

Habitat types favored by Red-breasted Nuthatches in the higher elevations of the Appalachians include spruce–fir forest, mature spruce forest, and mixed spruce–hardwood forest (Simpson 1976, Hall 1983). In the Smokies, Kendeigh and Fawver (1981) found this species in spruce–fir climax forests between 1760 m and 1790 m at concentrations of 20 pairs per 40 ha, but this species was not detected in seral spruce–fir forests above 1795 m. This species can occasionally be found nesting in high-elevation northern hardwood forests, with the presence of even a small amount of spruce being sufficient to produce a nesting population (Hall 1983). In North Carolina, Red-breasted Nuthatches also nest where Red Spruce ranges well below that of Fraser Fir, in a transitional zone of spruce–hemlock–deciduous forest between 1372 m and 1676 m in the southern Blue Ridge (Catlin 1984, Renfrow 2003).

Below the range of Red Spruce, summering Red-breasted Nuthatches have been found in old-growth hemlock, hemlock–deciduous, hemlock–white pine, and white pine forests at elevations between 1097 m and 1341 m in the southern Blue Ridge (Holt 1974, Simpson 1976). In the Smokies, Kendeigh and Fawver (1981) found this species in hemlock–deciduous forests between 873 m and 1356 m at concentrations of 11 pairs per 40 ha, as well as in pine heath forests between 1219 m and 1349 m at concentrations of 7.3 pairs per 40 ha.

At elevations below 860 m, breeding populations of Red-breasted Nuthatch are found in mixed forest invariably containing a strong element of Eastern White Pine, Eastern Hemlock, Red Maple (*Acer rubrum*), Sweet Birch (*Betula lenta*), and various oaks (*Quercus* spp.), as well as a significant component of "hard" pine species such as Pitch (*P. rigida*), Virginia (*P. virginiana*), and Shortleaf (*P. echinata*). Understory vegetation in these mixed forests is quite dense, consisting of a dense heath layer of one or more species of *Rhododendron*, Rosebay Rhododendron in particular, with Mountain Laurel present as well. These basic habitat elements are all present in lower-elevation Red-breasted Nuthatch nest site locations in Kentucky, Tennessee, West Virginia, Virginia, North Carolina, South Carolina, and Georgia. Extensive breeding-season searches in lower-elevation areas adjacent to nest areas (specifically, areas that lack one or more of these habitat elements) have been conducted from 1996 through 2005; these searches have failed to find any summering Red-breasted Nuthatches (Renfrow, unpubl. data).

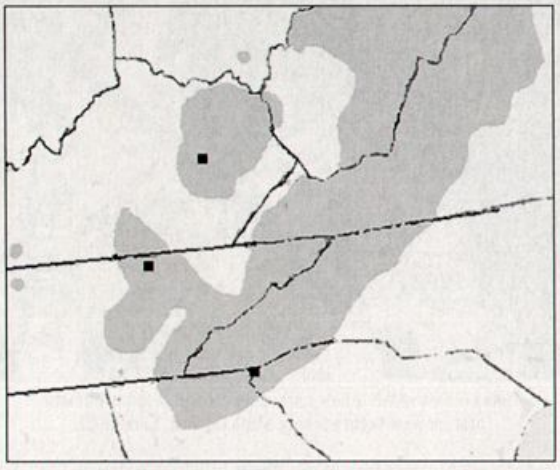

Figure 5. The natural range of Eastern White Pine, showing locations of recently discovered Red-breasted Nuthatch nest records in the Cumberland Plateau and Blue Ridge Escarpment.

These lower-elevation Appalachian forests with breeding Red-breasted Nuthatches combine elements from several forest types, including mixed mesophytic, hemlock–white pine–northern hardwoods and southern oak–hickory–pine. Braun (1950) described a forest of this type at Kentucky's Red River Gorge as a mixed mesophytic community like the hemlock–white pine–northern hardwoods forest but with an understory stratum of rhododendron, magnolia (*Magnolia* spp.), and holly (*Ilex* spp.) that lends the habitat a more southern aspect. Contrary to some descriptions of Appalachian forests as being sharply segregated by slope position and orientation, these forests are broadly integrated, with Eastern White Pine often dominating into the upper slopes, and with a considerable intermingling of Pitch, Shortleaf, and Virginia Pines into lower-slope areas. This forest type seems not to have been given a specific designation in earlier literature and might be best categorized as a white pine–hemlock–deciduous forest of a distinctly southern character. In the past, the characterization of forests as "hemlock–deciduous" may have caused the element of Eastern White Pine within this forest type to be overlooked. For example, Kendeigh and Fawver (1981) failed to mention Eastern White Pine in the context of their Great Smoky Mountain National Park study areas, including those in hemlock-deciduous forest, whereas Holt (1974) listed Eastern White Pine as second in abundance to Eastern Hemlock in hemlock–hardwood forests within her study areas at Highlands, North Carolina.

In the lower- to middle-elevation forests often described as pure hemlock or hemlock–deciduous, some element of an additional conifer species is most likely required for Red-breasted Nuthatch breeding, as the thin viscosity of Eastern Hemlock resin is apparently not suitable for nest entrance preparation: this species regularly coats the outside entrance of the nest hole with the more viscous resin of spruce, fir, or pine (Harrap and Quinn 1995), and access to at least a few such resin-producing conifers may be a minimal requirement to provide adequate habitat for nesting. At elevations below those required for fir or spruce, Eastern White Pine is most often found in close association with Eastern Hemlock. The resin of this pine species has been the most frequent source for nest preparation in the Kentucky, South Carolina, and Georgia nests of Red-breasted Nuthatch observed by this author (Figure 4). Pitch, Virginia, and Shortleaf Pine also have viscous resin suitable for the nest. Shortleaf Pine is listed as one of three southern pine species with resin chemistry suitable for use by Red-cockaded Woodpeckers (*Picoides borealis*) for producing resin-barriers that provide nest defense against rat snakes (*Elaphe* spp.) (Conner et al. 2003). Ghalambor and Martin (1999) suggest that Red-breasted Nuthatches construct similar resin barriers for reduction of both competitive and predatory interactions at the nest.

In lower- to middle-elevation situations, trees utilized for nesting by Red-breasted Nuthatch fall into two general categories. In some cases, nesting birds use a standing dead conifer trunk, usually with the top por-

Figure 6. Results of prescribed burn at Wolfe County, Kentucky, 12 May 2004. Note brown-needled Eastern White Pine saplings.

tion and most of the limbs broken off but with some bark still intact (particularly at the nest cavity entrance). Nest trees in such cases have included Pitch Pine, Eastern White Pine, Shortleaf Pine, and Eastern Hemlock. Other nests have been found in a dead portion of a living deciduous tree, often a Red Maple or Sweet Birch. These nests are usually excavated fresh in a new location each year.

The seeds extracted from cones of the Eastern White Pine are an important source of food for this nuthatch, as are insects gleaned from lichen-encrusted twigs and branches. In winter, this species can often be observed foraging in the deeper grooves, splits, and irregularities in the bark of these pines, especially at the circular whorls of branch junctures with the main trunk. The loose, flaky barks of Pitch, Virginia, and Shortleaf Pines also serve as favored foraging substrates. Both Eastern Hemlock and Eastern White Pine tend to produce heavy cone crops in which the cones quickly open upon ripening; the latter species produces cones biennially, thus limiting the availability of these food sources during many seasons. On the other hand, the cones of Pitch, Virginia, and Shortleaf Pine are persistent and slow to open (Holmes 1959), providing a more dependable food source from year to year. Additionally, the deciduous element of the forest provides foraging substrates, with the smaller lichen-encrusted branches of oaks possibly being more frequently probed and inspected than those of the surrounding conifers in these mixed-forest environments, especially during the nesting season (Renfrow, unpubl. data).

During searches conducted in lower-elevation areas of the Appalachians, areas possessing all of the above-mentioned forest elements—but lacking a dense heath understory stratum—have not been found to contain Red-breasted Nuthatches, for reasons that are not clear. The same is not true in planted pine areas farther north. Although this species forages readily on the ground in clearings associated with trails, trampled openings, and even grassy areas, it can occasionally be found foraging low among the rhododendron foliage. Close association of Rosebay Rhododendron with Eastern White Pine and Eastern Hemlock within their ranges in the southeastern United States may account for this apparent inconsistency, as might the apparent close association of the lower-elevation Appalachian populations of Red-breasted Nuthatch with those of Swainson's Warbler (Renfrow and Stedman 2003). Old-growth hemlock forests in both middle- and lower-elevation areas are notable for their prodigious understory stratum of Rosebay Rhododendron, as noted by Brewster (1886), Holt (1974), and Renfrow (2003).

Red-breasted Nuthatch range expansion in relation to Eastern White Pine distribution

The discovery of breeding Red-breasted Nuthatches on the Cumberland Plateau calls into question its general designation as a "northern-affinity" species. These disjunct pockets of breeding occurrence are considerably removed from the breeding ranges of other passerine species considered to possess northern affinities. Haney (1999) lists Red-breasted Nuthatch with Brown Creeper (*Certhia americana*), Winter Wren (*Troglolytes troglodytes*), and Golden-crowned Kinglet (*Regulus satrapa*) as species forming a recurring group that exploits coniferous cover and complex structure typical of older natural forests across broad geographical domains. These other species do extend their breeding ranges from higher elevations into the Blue Ridge Escarpment Gorges of South Carolina but have no known breeding populations on the Cumberland Plateau (Stedman and Stedman 2002, Palmer-Ball 2003, Renfrow 2003). Blue-headed Vireo (*Vireo solitarius*) and Black-throated Green Warbler, two Neotropical migrant species that share this same habitat and are sometimes thought of as northern-affinity species, both have breeding ranges that extend far to the south, well into the Piedmont region of Georgia (Beaton et al. 2003).

Outside of the range of the spruce–fir forest, the natural range of Eastern White Pine (Figure 5) may well be the key component delimiting the historic as well as the recently expanded range of Red-breasted Nuthatch within the southeastern United States. This natural range extends along the Appalachian Mountains southward through the Blue Ridge Mountains of South Carolina and Georgia, with one major lobe extending westward through the Ridge and Valley into Tennessee's Cumberland Plateau and a discontinuous section encompassing the northern portion of the Cumberland Plateau in Kentucky (Little 1970).

Tentative conclusions: Red-breasted Nuthatch range expansion and habitat change

Known Red-breasted Nuthatch breeding populations within lower-elevation areas of the southeastern United States are relatively few at present, but further expansion into areas of maturing mixed white pine–hemlock–deciduous forest might be expected with the continued degradation of spruce–fir forests in higher-elevation areas. Kendeigh and Fawver (1981) cite overflow from nearby spruce–fir forests as a possible explanation for breeding presence of Red-breasted Nuthatch, Brown Creeper, Winter Wren, and Golden-crowned Kinglet in the hemlock communities of the Great Smoky Mountains National Park.

Askins (2000) lists Red-breasted Nuthatch among avian species primarily associated with undisturbed spruce and fir forests. At present, it is not clear to what extent the severe disease in southern spruce–fir forests will affect populations of this species, but population declines have already been detected in some areas. During the late 1990s, Red-breasted Nuthatches were reported to be scarce in their usual stronghold in the spruce belt of the Cheat Mountains (Hall 1997). Rabenold et al. (1998) list Red-breasted Nuthatch with Black-capped Chickadee (*Poecile atricapillus*), Brown Creeper, Winter Wren, and Golden-crowned Kinglet as species having declined measurably where adelgid infestations have caused dramatic changes in the spruce–fir forest structure within Great Smoky Mountains National Park. Brewster (1886) listed Red-breasted Nuthatch with Winter Wren and Golden-crowned Kinglet as the most abundant species in the spruce forests of western North Carolina: the call of the nuthatch is described as almost omnipresent in these areas. As in Brewster's time, Red-breasted Nuthatches can still sometimes be heard three or four at a time in higher-elevation areas, but such abundance now seems to be the exception rather than the rule. Conversely, populations in some lower-elevation areas appear to be on the increase; for instance, numbers surveyed along Willis Knob Road in Rabun County, Georgia were found to be comparable to those along Clingman's Dome Road at Great Smoky Mountains National Park in June 2004 (Renfrow, unpubl. data).

A considerable portion of the breeding habitat of Red-breasted Nuthatch in the southeastern United States occurs on lands designated as National Forest, and these areas contain an estimated 25 per cent of hemlock–white pine forests in the Southern Appalachians (Hunter et al. 1999). Management for increased protection of the mixed white pine–hemlock–deciduous forest type would be strongly indicated for the protection of the Red-breasted Nuthatch. At present, the Hemlock Woolly Adelgid presents a serious threat to these forests (LeGrand 2004), and the implementation of adelgid control measures is of critical importance. The United States Forest Service has initiated one adelgid control measure, namely the release of the coccinellid beetle *Pseudoscymnus tsugae* in selected locations within the Chattahoochee National Forest in 2004. This beetle is a highly specialized predator, feeding almost exclusively on the Hemlock Woolly Adelgid and possibly other similar adelgid species (Jensen 2004; S. Cole, pers. comm.). Further expansion of use of this control measure could help to preserve the remaining hemlock constituent of the Appalachian forests.

Other concerns with regard to Red-breasted Nuthatch habitat include the effects of fire and of logging. Recent planning strategies utilizing prescribed burns in National Forest areas, such as a prescribed burn in 2004 (Figure 6) at the Rock Bridge area in Kentucky (B. Palmer-Ball, pers. comm.; K. Huie, pers. comm.) and several recent prescribed burns within the Chattahoochee National Forest in Rabun County, Georgia (A. Gaston, pers. comm.), could reduce Red-breasted Nuthatch populations locally. This species appears to have a strong affinity for structural features of old-growth forests and mature, undisturbed forests, is adversely affected by forest fragmentation, and appears to shun heavily burned areas (Ghalambor and Martin 1999, Haney 1999, Askins 2000).

Commercial pressure to resume or expand logging in white pine–hemlock–deciduous forests likewise continues to be a concern. The use of prescribed burns, selective logging of conifers, or clearcutting could be detrimental to Red-breasted Nuthatch populations, as could any management practice that inhibits growth of Eastern White Pine and Rosebay Rhododendron. Other passerine species that breed in significant numbers in these mixed forests include Blue-headed Vireo, Red-eyed Vireo (*Vireo olivaceus*), Northern Parula (*Parula americana*), Black-throated Green Warbler, Swainson's Warbler, Black-and-white Warbler (*Mniotilta varia*), Worm-eating Warbler (*Helmitheros vermivorus*), Ovenbird (*Seiurus aurocapillus*), Louisiana Waterthrush (*Seiurus motacilla*), and Hooded Warbler (*Wilsonia citrina*): the avifaunal richness of this lower-elevation Appalachian habitat is clear. Concerns regarding loss of biodiversity within the herbaceous layer and changes in forest succession due to the predominance of Rosebay Rhododendron and Mountain Laurel in the understory stratum (George and Bazzaz 2003) need to be balanced with concerns for protection of existing bird habitat in these areas.

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