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CHANGES IN THE SPRUCE–FIR AVIFAUNA OF MT. GUYOT, TENNESSEE, 1967–1985

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ABSTRACT

In 1967 a breeding bird census was conducted on a 24.28 ha plot in a virgin red spruce–Fraser fir forest on Mt. Guyot in Great Smoky Mountains National Park. The survey was made prior to infestation of Fraser fir by the introduced balsam woolly aphid. In 1985 an effort was made to duplicate the original census on the same plot after aphid infestation and the subsequent destruction of most of the old-growth spruce–fir forest. Two territorial species present in 1967 were absent in 1985, and three new early successional species were present. Most of the 11 species present during both census years had decreased in density.

INTRODUCTION

The highest unglaciated ridges of the Southern Appalachian Mountains in western North Carolina and East Tennessee are mantled with a spruce–fir forest similar to the boreal coniferous forest of Maine and adjacent Canada. Similar forests occur in isolated stands from Virginia, West Virgina, and the Pocono Mountains in eastern Pennsylvania, into New England and Canada. They extend southwestward like a string of biotic islands stretching further and further from a northern mainland continent into the Great Smoky Mountains of Tennessee. The principal tree of this forest is red spruce *(Picea rubens)*, which reaches its lower elevational limit in the Smokies at around 1300 m. At higher elevations it is joined by the endemic Fraser fir (Abies fraseri), which grows in almost pure stands on the highest summits.

The avian communities of the Southern Appalachian Mountains are a unique subset of the family of communities extending into New England and southeastern Canada, united and defined by the dominance of red spruce (Rabenold 1984). These avifaunas are stable (Hall 1989), clearly boreal in character, and strikingly distinct from those of lower-elevation deciduous forests (Rabenold 1984). In at least one major attribute these bird communities conform to the island biogeography theory of MacArthur and Wilson (1967); their species richness is low compared to communities in the extensive boreal coniferous forest of New England and Canada (Alsop 1969, Rabenold 1984, Hall 1989). Despite the lower species richness, the southern spruce–fir forest may have higher densities of breeding birds (Alsop 1969, Rabenold 1984, Hall 1989).

In 1908 the balsam woolly aphid *(Adelges piceae)* was accidently introduced from Europe into Maine (Kotinsky 1916, Stupka 1964). It was first detected in the Great Smoky Mountains National Park on Mt. Sterling, North Carolina, in August 1963 (U.S. Departments of Agriculture and Interior 1964). Fraser fir is highly susceptible to attack by the aphid, with death occurring within two to five years after initial colonization of an individual tree by the aphid (Amman and Speers 1965). All Fraser fir stands within the park are now infected (Eagar 1984), and the death of all mature fir trees is likely by the mid-1990s (Nicholas and White 1985).

In June 1967, a breeding bird census was conducted in the virgin spruce–fir forest on Mt. Guyot, Great Smoky Mountains National Park (Alsop 1968, 1969). The census was conducted prior to the occurrence of the aphid on Mt. Guyot, to gather baseline data for use in later comparative studies. Analyses of the vegetation of the study plot were made concurrently. In June 1985, after more than a decade of aphid infestation on Mt. Guyot, this breeding bird census was repeated.

METHODS

On Mt. Guyot the 1967 study site was reestablished in 1985 from remembered landmarks and by measurements of known distances from the trailhead. We established a grid of 40 squares (stations), each approximately 78 m on a side and embracing 0.6 ha. The completed 24.28 ha, L-shaped grid was a replicate of the 1967 study site in size, configuration, and location. The dominant plant association at the 1816.6 m USGS benchmarked elevation of the study site was that of the spruce–fir forest of the Canadian Zone Biome.

Identical methods of vegetation analysis were used for both the 1967 and 1985 studies. The forest was partitioned into three vertical divisions—forest crown, understory, and ground cover—defined as follows: *forest crown* – those woody plants having a height in excess of 7.6 m; *understory* – those woody plants with a height not in excess of 7.6 m; and *groundcover* – those nonwoody, vascular plants having a height greater than 2.54 cm, but less than 91.4 cm. A quantitative survey of the forest crown vegetation of the census area was made by taking a sample plot count at each grid intersection. Circular plots of 3.04 m radius were used and the numbers and species of trees (both living and dead) within each plot were recorded. Understory and groundcover plants within these circular plots were identified and recorded.

Breeding bird counts were made by Laughlin on 12 consecutive days from 19 through 30 June 1985. Counts were made each morning soon after daylight, and on all but four afternoons (which were rained out), using the Williams spot mapping method (Hall 1964). Twenty counts were made in 1985, compared to 15 counts (9 morning and 6 afternoon) over 10 consecutive days (17–26 June) made in 1967.

RESULTS

Vegetation

A comparison of the compositions of the 1967 and 1985 forest crown trees is shown in Table 1. In the 1967 study the predominant tree was Fraser fir, comprising 80% of the standing timber. In close association with the fir was red spruce, a larger conifer that made up 16% of the forest crown. Yellow birch *(Betula lutea)*, scattered among the spruces and firs mostly as solitary individuals, comprised the remainder of the canopy. By 1985 the formerly closed canopy had been replaced by an open canopy characterized by stems much further apart, more standing dead conifers, an almost complete absence of Fraser fir, and a dramatic decrease in the abundance of canopy trees.

Table 1. A comparison of the forest crown trees[a] on 0.175 ha of the Mt. Guyot study area before and after aphid infestation.

	Number of trees		Relative Abundance: Percent of total trees		Percent change in number of trees
Tree species	1967	1985	1967	1985	
Fraser Fir	529	3	80	2.5	-99.5
Red Spruce	107	91	16	80	-15
Yellow Birch	26	17	4	15	-35
Mountain Maple	0	3	0	2.5	
Totals	662	114	100	100	-83

[a]Living trees only; in the 1985 study 243 standing dead conifers (68% of the standing trees), primarily fir, were on the survey plots.

Standing dead conifers made up 68% of the timber on the 1985 sample plots. There had thus been a loss of approximately 83% of the living canopy trees, and a loss of Fraser fir from the canopy of 99.5%. In 1985 red spruce was the predominant tree species, comprising 80% of the living forest crown trees; yellow birch, at 15%, and mountain maple (Acer spicatum) and Fraser fir, at 2.5% each, made up the rest of the living canopy. In 1967 the stems of the living crown trees averaged 1.82 m apart; in 1985 this average distance had increased to 3.65 m.

The 1967 understory had a few scattered deciduous trees that approached 8 m in height *(Pyrus americana* and *Acer spicatum)*; most of the understory was less than 2 m tall and was composed of *Vaccinium erythrocarpum, Viburnum alnifolium, Rubus canadensis,* and young spruce and fir. Blackberry was found only in small patches where breaks in the canopy allowed increased sunlight to reach the forest floor. Only the Vaccinium and the fir saplings were in stands covering areas in excess of 18 m square.

The opening up of the canopy which resulted from the loss of the firs allowed more light to reach the understory, resulting in the growth of extensive, dense stands of such shrubs as Rubus, Vaccinium, and Viburnum. Thornless blackberry *(Rubus canadensis)* was the most abundant plant on 19% of the 1985 sample plots. It occurred as tangled thickets less than 92 cm in height on 29% of the plots, and at heights tall enough to be classified as part of the understory on 48%.

In 1967 the groundcover (excluding mosses and lichens) was comprised of extensive stands of *Oxalis montana* growing wherever there was sufficient substrate. It covered the ground, fallen tree trunks, and the bases of living trees. Growing above the Oxalis, and almost equally abundant, was lady fern *(Athyrium asplenioides)*. So dense was the growth of these two species it was difficult to see the humus of the forest floor. In areas where more light penetrated, small stands of *Senecio rugelia* occurred. In the 1985 forest, lady fern was more abundant and was almost twice as common as Oxalis on the sample plots. Athyrium had become as common on the site as Oxalis, being recorded on 52% of the plots.

Unlike the 1967 forest, the ground in 1985 was crisscrossed with the trunks, tangled limbs, and debris of many wind–felled trees. The loss of foliage from the aphid–infected firs created wide alleys that allowed winds to push more strongly against the dead, dying, and living trees alike. The loss of the dominant fir has contributed to the loss of many living spruce and birch trees through this blow–down process.

Avifauna

The number of territorial species found in June 1985 is very similar to the number recorded on the same plot in 1967 (14 and 13, respectively). But the net gain of one species occurred through a loss of two species present in 1967 and the addition of three species not present in 1967 (see Figure 1). Probably the most significant impact of the loss of the fir and the resulting opening up of the canopy was the dramatic drop in the density of territorial bird populations breeding on the study plot; from a density of 280 males per 40 ha in 1967, the density fell to 182 males per 40 ha in 1985. This represents a decrease in the breeding bird population density of 35%. A chi–square test for homogeniety of these two population densities indicates the change is highly significant ($p < 0.001$).

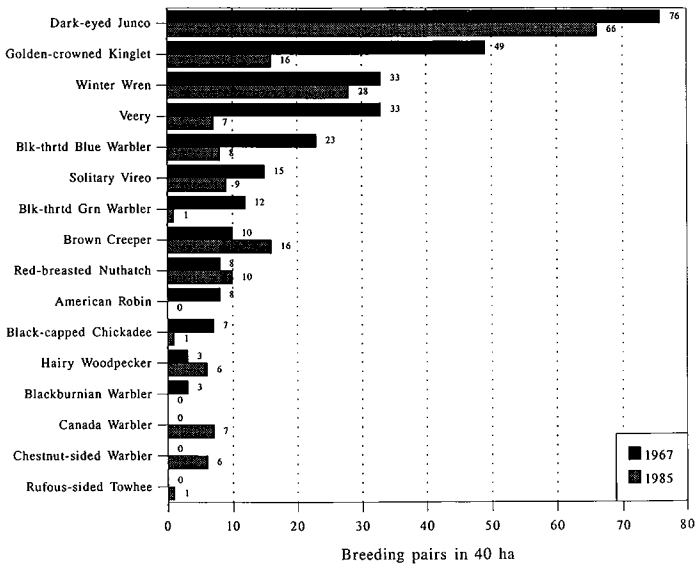

Figure 1. A comparison of the population densities of mid–June breeding birds of the Mt. Guyot spruce–fir forest, before (1967) and after (1985) aphid infestation.

Discussion

The virgin spruce–fir forest of the 1967 census—remote from human disturbances, homogeneous, and with a closed canopy—was dramatically altered by the aphid. By 1985, three bird species not recorded in 1967 were present: Canada Warbler, Chestnut–sided Warbler, and Rufous–sided Towhee. All three of these species require edge and dense clumps of undergrowth for nesting and foraging. The extensive opening up of the forest canopy that occurred between 1967 and 1985 promoted such habitats at the site. Thirteen of the 16 species of birds recorded as territorial on Mt. Guyot are at or near the southernmost limit of their breeding ranges there, and their breeding populations in the Smokies are rather small (compared to northern populations), scattered (because of the patchy distribution of the spruce–fir forests), and isolated. Of the 10 species that decreased in numbers between the 1967 and 1985 censuses, five are long–distance neotropical migrants and five are permanent residents that move to the lower elevations during the winter. Compared with the situation in northern spruce–fir forests, few warblers breed in the spruce–fir forests of the Southern Appalachians, and the numerically dominant species are either permanent residents or short–distance migrants such as the Dark–eyed Junco, Winter Wren, and Golden–crowned Kinglet. These three species accounted for 56% of the individuals in 1967 and 60% in 1985. Rabenold (1984) suggests that even the structure of the spruce–fir bird communities may be vulnerable to changes in their low–elevation wintering grounds if formerly cleared areas within the Park are allowed to revert naturally to forest. Such wintering bird populations could be forced outside the Park boundaries where they could suffer from effects of shrinking habitat.

Populations of birds in the spruce–fir forests of the Southern Appalachians have remained stable for many years (Brewster 1886, Hall 1989), but the wholesale destruction of the forest by insects and airborne pollutants in the past three decades has imposed severe tests on the stability of this avifauna. One of the most distinctive ecosystems in these southern mountains is also apparently one of the most threatened. The mature Fraser fir is nearly gone. Airborne pollutants and windthrow threaten the red spruce. Opening up of the canopy has altered microclimatic conditions and promoted the growth of shrubs, blackberry, and ground cover. As a result of these changes, bird species requiring a canopy of spruce and/or fir have been adversely affected. If the lower–slope deciduous forest invades upslope, its resident bird species will follow, changing further the boreal character of the avifauna (Rabenold 1984).

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