

EFFECT OF CLEARCUT BORDERS ON DISTRIBUTION AND ABUNDANCE OF FOREST BIRDS IN NORTHERN NEW HAMPSHIRE

DAVID I. KING,¹ CURTICE R. GRIFFIN,¹ AND RICHARD M. DEGRAAF²

ABSTRACT.—We compared numbers of forest bird territories between forest edge and forest interior areas to determine whether clearcuts affect bird abundance in adjacent forest. We then simulated the distribution of territories that would be expected if birds were neither attracted to nor repelled by clearcut borders by randomly locating 100 1-ha circular “simulated” territories on scale maps of the study plots, with the condition that simulated territories were located entirely within mature forest. Plots were divided into successive 50-m distance classes extending from clearcut borders 300 m into forest interior, and the distribution of territories of each species among 50-m distance classes was compared with the distribution of simulated territories. Red-eyed Vireos (*Vireo olivaceus*) and Hermit Thrushes (*Catharus guttatus*) were less abundant in edge areas, but the distribution of these species did not differ from the distribution of randomly placed simulated territories. We conclude that lower abundance of forest birds in edge areas is not necessarily evidence of edge avoidance but may be merely the result of the absence of suitable habitat beyond clearcut borders. *Received 27 Feb. 1996, accepted 20 Nov. 1996.*

Forest fragmentation is an important factor in the decline of many populations of forest-dwelling Neotropical migrant birds (Robinson et al. 1995). A phenomenon associated with the process of forest fragmentation is an increase in the proportion of the remaining habitat consisting of edge (Temple 1986). Edges affect forest birds in a number of ways. Some forest bird species appear to avoid edges, possibly because of changes in vegetation structure (Gates and Gysel 1978, Strelke and Dickson 1980, Kroodsmas 1984) or because of high rates of nest predation near edges (Gates and Gysel 1978, Temple and Carey 1988, King et al., in press). In this study, we tested whether clearcutting affected the abundance of birds in forest adjacent to clearcuts by comparing numbers of forest bird territories between edge and forest interior areas.

Lower abundance of forest birds near edges is generally interpreted as evidence of edge avoidance; however, it has been suggested that lower abundance of forest birds could result from the restriction of these species to mature forest habitat rather than active edge avoidance (Kroodsmas 1984, Rich et al. 1994). Therefore, we simulated the distribution of territories that would be expected if forest birds were restricted to mature

¹ Dept. of Forestry and Wildlife Management, Univ. of Massachusetts, Amherst, Massachusetts 01003.

² USDA Forest Service Northeast Forest Experiment Station, Univ. of Massachusetts, Amherst, Massachusetts 01003.

forest but otherwise located territories at random with respect to clearcut borders. Observed distributions of forest bird territories were compared with the distribution of simulated territories to test if there was evidence of active edge avoidance or if distributions of forest bird territories relative to clearcut borders could be explained by the restriction of these species to mature forest habitat.

STUDY AREA AND METHODS

Four study plots were established in mature (≥ 80 yrs old) northern hardwoods forest adjacent to three recent (≤ 6 yrs) clearcuts on the Saco District of the White Mountain National Forest in northern New Hampshire ($44^{\circ}03'N$, $71^{\circ}15'W$). Bird territories were mapped on each plot using a modified spot-mapping technique (Holmes and Sturges 1975): Two skilled observers walked slowly ($1.2 \text{ km} \cdot \text{h}^{-1}$) along parallel transects placed 100 m apart, recording the species and location of all birds seen or heard on scale maps of the study plots. Each transect extended from 50 m within the clearcut, across the clearcut border, and 350 m into the forest interior. Surveys were conducted within 1.5 h of sunrise, and both the direction transects were walked and the observers were alternated among surveys. Eight transect counts were conducted on each plot between May and August in 1992 and 1993. Bird data were transferred onto transparent drafting film. A polygon connecting a cluster of three or more observations of an individual was designated as a territory of that species, and evidence of counter singing was used to separate adjacent territories (Robbins 1970). Only species for which ≥ 10 territories were mapped were included in the analyses (Strelke and Dickson 1980).

We compared the number of territories of individual bird species between 0–100 m (hereafter “edge areas”) and 200–300 m (hereafter “interior areas”) from clearcut borders using G-tests (Zar 1984:77). Data collected between 300–350 m were not analyzed to avoid the inclusion of partially mapped territories. Additionally, we simulated the distribution of territories that would be expected if forest birds were locating their territories randomly in relation to clearcut borders by drawing 100 1-ha circular territories at randomly located points on scale maps of the study areas, with the condition that territories were situated entirely within mature forest. (1-ha territories correspond to the territory size of many common Neotropical migrant bird species present on our study sites; DeGraaf and Rudis 1986). Study plots were divided into successive 50-m distance classes extending from clearcut borders 300 m into forest interior. The distribution of actual territories was compared with the distribution of simulated territories using the Kolmogorov-Smirnoff goodness-of-fit test (Zar 1984:53). The number of simulated territories was also compared between edge and interior areas using G-tests, after scaling the number of simulated territories equal to the total number of the most abundant bird species in our study. This procedure eliminated the possibility that differences in number of simulated territories between edge and interior areas might be a result of increased statistical power due to large sample size ($N = 100$ simulated territories). The distribution of forest bird territories among 50-m distance classes was compared between years using the Kolmogorov-Smirnoff goodness-of-fit test. No significant differences were detected ($p > 0.10$), so data were pooled between years.

Average tree height, average canopy height, percent canopy cover, percent herbaceous cover, shrub density and tree basal area were measured on 80 randomly located 0.04-ha circular plots (Noon 1981). Two 22.3-m long transects were established on each plot, oriented in the cardinal directions and intersecting the plot center. The tree closest to the plot center in each of the four quadrants formed by the intersection of the two transects was

TABLE 1
NUMBER OF BIRD TERRITORIES IN EDGE AND INTERIOR AREAS

	Edge	Interior	G	df	P
Red-eyed vireo (<i>Vireo olivaceus</i>)	9	18	3.20	1	0.07
Ovenbird (<i>Seiurus aurocapillus</i>)	11	12	0.00	1	1.00
Black-throated Green Warbler (<i>Dendroica virens</i>)	5	8	0.50	1	0.48
Black-throated Blue Warbler (<i>D. caerulescens</i>)	10	2	5.78	1	0.02
American Redstart (<i>Setophaga ruticilla</i>)	4	4	0.00	1	1.00
Scarlet Tanager (<i>Piranga rubra</i>)	4	7	0.84	1	0.36
Hermit Thrush (<i>Catharus guttatus</i>)	2	8	3.74	1	0.05
Simulated Territories	8.4	19.2	4.34	1	0.04

selected and the height of the crown and lowest branch in the canopy were measured in meters using a clinometer. Percent canopy and herbaceous cover were measured at 20 regularly spaced intervals along the two transects using a sighting tube (Noon 1981). Shrub density at breast height was estimated by counting the number of stems ≤ 3 cm dbh contacting the outstretched arms and body of an observer walking the length of the two transects and multiplying the result by 125 to convert to stems-ha⁻¹ (Noon 1981). Basal area (in m²-ha⁻¹) was estimated on each plot for all species combined and for conifers considered separately using a ten-factor prism. Habitat variables were log transformed where necessary to improve normality and equality of variances (Zar 1984:238) and compared between edge and interior areas using two-sample *t*-tests (Zar 1984:126). Statistical analyses were done using STATISTIX (1992, Analytical Software Inc.). Statistical significance was set at *P* = 0.10.

RESULTS

Seven bird species were included in the analyses (scientific names in Table 1). Red-eyed Vireos and Hermit Thrushes were significantly less abundant in edge areas than forest interior areas. Black-throated Blue Warblers were significantly more abundant in edge areas than forest interior areas. Numbers of Ovenbirds, Black-throated Green Warblers, American Redstarts, and Scarlet Tanagers did not differ significantly between edge and interior areas. Simulated territories were less abundant in edge areas (Table 1).

The distribution of territories of four bird species did not differ from the distribution of randomly placed simulated territories (Fig. 1): Red-eyed Vireo (*D* = 0.13, *P* = 0.92, *N* = 45), Ovenbird (*D* = 0.18, *P* = 0.62, *N* = 37), Black-throated Green Warbler (*D* = 0.14, *P* = 1.00, *N* = 24), and Hermit Thrush (*D* = 0.22, *P* = 0.48, *N* = 13). In contrast, the distribution of territories of Black-throated Blue Warblers and American Redstarts were skewed significantly towards clearcut borders (*D* = 0.50, *P* = 0.004, *N* = 24; *D* = 0.53, *P* = 0.02, *N* = 24; Black-throated Blue Warblers and American Redstarts, respectively). The distribution of Scar-

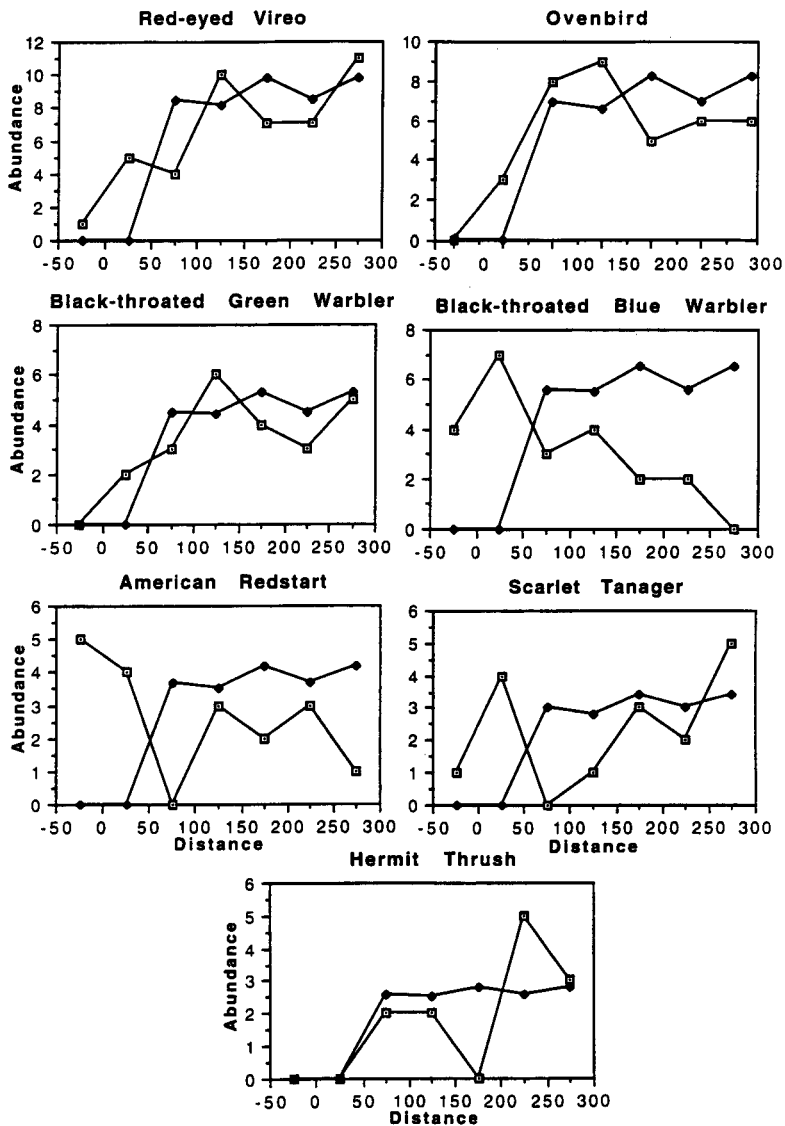


FIG. 1. Distribution of territories of forest bird species (open squares) compared with the distribution of simulated territories (black diamonds). Values on the X-axis represent successive 50-m intervals from 50 m within clearcuts to 300 m within forest interior.

let Tanager territories differed significantly from the distribution of simulated territories but was not clearly skewed towards either edge or interior ($D = 0.31$, $P = 0.08$, $N = 16$; Fig. 1).

Basal area, basal area of conifers, canopy cover, herb cover, canopy height, and tree height did not differ between edge and interior areas ($P > 0.10$). Shrub density was lower in edge areas ($t = 3.24$, $P = 0.002$, $df = 78$).

DISCUSSION

Various hypotheses have been advanced to explain lower abundance of forest birds near edges. One proposal is that forest birds actively avoid edges because of high rates of nest predation in these areas (Gates and Gysel 1978, Temple and Carey 1988, King et al., in press). However, it is unlikely that birds in regions where disturbance has been historically uncommon (such as our study area; Hornbeck and Leak 1991) have had the opportunity to evolve edge avoidance behavior (Kroodsma 1984, Ratti and Reese 1988, Van Horn et al. 1996). Another possibility is that differences in bird abundance between edge and interior areas is the result of changes in vegetation structure near edges (Gates and Gysel 1978, Strelke and Dickson 1980, Kroodsma 1984). However, according to published accounts of forest bird habitat use in our region (DeGraaf and Rudis 1986, Thompson and Capen 1988), there were no differences in vegetation parameters that would account for the differences we observed in Red-eyed Vireo and Hermit Thrush abundance between edge and interior areas.

An alternative explanation is that lower numbers of Red-eyed Vireo and Hermit Thrush territories in edge areas is an artifact of the restriction of these species to mature forest habitat. Rich et al. (1994) compared the abundance of forest bird species between forest edge and forest interior areas and concluded that lower abundance of forest birds near edges was the result of the absence of suitable habitat beyond edges rather than active edge avoidance. A similar explanation was proposed by Kroodsma (1984) to account for the displacement of forest bird territories away from powerline right-of-ways in east Tennessee. We argue that for birds that are restricted to mature forest habitat, territory centers will be displaced away from edges the distance of the radius of the territory. The potential for this type of displacement to appear as active edge avoidance is further illustrated by our observation that randomly located simulated territories were significantly less numerous in edge areas. Furthermore, the only species which had distributions shifted towards clearcut borders (Black-throated Blue Warbler and American Redstart) were also the only species we observed regularly defending territories in clearcuts.

One potential criticism of our territory simulation is that forest bird territories may become compressed near clearcut borders, whereas we assumed that territories are round, on average. If simulated territories were elongated rather than round, with their long axes parallel to clearcut borders, differences in numbers of simulated territories between edge and interior areas would have been less pronounced and distributions among 50-m distance classes would have been less skewed away from clearcut borders. Although birds that favor edge habitats are reported to alter the shape of their territories near edges, forest dwelling birds do not generally exhibit this behavior (Johnston 1947, Whitcomb et al. 1981, Kroodsma 1984, King, unpubl. data). Therefore, it appears the use of circular territories in our simulation is valid, at least for heuristic purposes.

We conclude that lower abundance of forest birds near edges is not necessarily evidence that forest birds avoid edges. Nevertheless, many of the practical considerations for natural resource managers are the same, regardless whether patterns of forest bird territory distribution are due to active edge avoidance or not. Of more significance are the implications for research on edge effects and forest birds. An unambiguous demonstration that forest birds avoid edges is necessary before the mechanisms underlying edge avoidance in birds can be meaningfully addressed.

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