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# Effects of even-aged management on forest birds at northern hardwood stand interfaces

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ABSTRACT

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Breeding birds were counted along transects across edges of even-aged northern hardwood stands in the White Mountain National Forest, New Hampshire, U.S.A. Two replicate transects across each of 7 edge types representing 3 classes of contrast (abrupt, intermediate, and subtle) were sampled during June 1983–1985 to define species assemblages at stand edges and estimate the width and longevity of functional edges under even-aged management. Of 52 bird species, 28 occurred across all three classes of edges, but no unique species or assemblages were evident at the edges between stands. Across edges between young stands, bird species richness declined linearly from seedling stand interior to pole stand interior, but no differences in cumulative bird species richness by edge contrast type were found. The proportion of edge-detected species was higher in the younger stand in all edge contrast types except the most subtle edge type between mature stands. Only across seedling–sawlog and sapling–large sawlog edges were bird assemblages more different than similar. Edge "avoidance" was pronounced when stands were most different. The distributions of foraging and nesting guilds differed ($P < 0.05$) only when seedling or sapling stands abutted stands that were pole-sized, or larger. Edges between even-aged northern hardwood stands, even of greatly contrasting age or height, are different from field–forest edges. Northern hardwood clearcuts regenerate rapidly and do not develop a grass stage nor a brushy border. Foliage profiles in stands of widely disparate ages are similar, and effects of boundaries between even-aged stands on breeding birds are ephemeral.

## INTRODUCTION

Edge effect is normally defined as the tendency for variety and density of organisms to be greater at the borders between plant communities than in their respective interiors (Odum, 1971:257). This paper focuses on the species variety aspect of the concept. Higher densities of birds along edges between forests and more open habitats have been reported for a long time (Lay, 1938;

Johnston, 1947; Anderson et al., 1977). The edge effect is especially pronounced along edges where forests border open habitats; at such edges, brush-dwelling birds are confined to the forest edge because of the lack of shrubs or singing posts in the open habitat (Gates and Gysel, 1978; Kroodsma, 1984). At edges between pine-hardwood forest (> 30 yrs old) and clearcuts (< 3 yrs old) in East Texas, breeding bird species richness, diversity (H′), and abundance were higher in the first 25 m of the forest edge than in other sections of the forest or clearcut (Strelke and Dickson, 1980). Concentrations of woods-associated species occurred at the forest edge, species associated with clearcuts used the forest edge for foraging and for singing posts, and some species were found mostly in the edge, presumably due to the greater number of foliage layers at the edge.

The breeding bird assemblages within stands of New England northern hardwoods, primarily sugar maple (*Acer saccharum*), yellow birch (*Betula alleghaniensis*) and beech (*Fagus grandifolia*), are generally known. Four distinct bird species groups reflect habitat differences in seedling (< 2.5 cm dbh), sapling (2.5–12.5 cm dbh), pole-timber (13–30.0 cm dbh), and "mature" (> 30.0 cm dbh) stands. The most dramatic differences occur among the smaller size-classes; breeding bird composition is essentially unchanged in stages beyond the pole stage. Even-aged sawlog stands (80 to 125 yrs old, 31–40 cm dbh), large sawlog stands (>150 yrs old, >40 cm dbh) and uneven-aged stands all have similar avifaunas (DeGraaf, 1987).

Surveys in interiors of New England northern hardwood stands have shown that seedling stands average 28 breeding bird species (DeGraaf, 1987). Of these, five occur only in that stage. Sapling stands contain about 30 species; six passerine species and drumming male ruffed grouse (*Bonasa umbellus*) reach their highest densities in sapling stands. Pole stands contain 14 species; none are unique to that stage. The breeding bird assemblages of sawlog stands, large sawlog stands, and uneven-aged stands all contain approximately 30 species (DeGraaf, 1987).

This study reports results of bird surveys across northern hardwood forest edges of various types of contrast. The objectives were to: (1) identify the breeding bird assemblages at edges between even-aged stands, (2) estimate the width of functional edges for bird species or groups, and (3) estimate the longevity of functional edges under even-aged management.

## METHODS

The study was conducted on the White Mountain National Forest in New Hampshire. The region is one of extensive forest; nonforest upland openings are few and widely scattered. Breeding birds were sampled across 7 edge types that are routinely created when even-aged silviculture is used to produce a sustained yield of wood products (Fig. 1). Edges result when the clearcutting

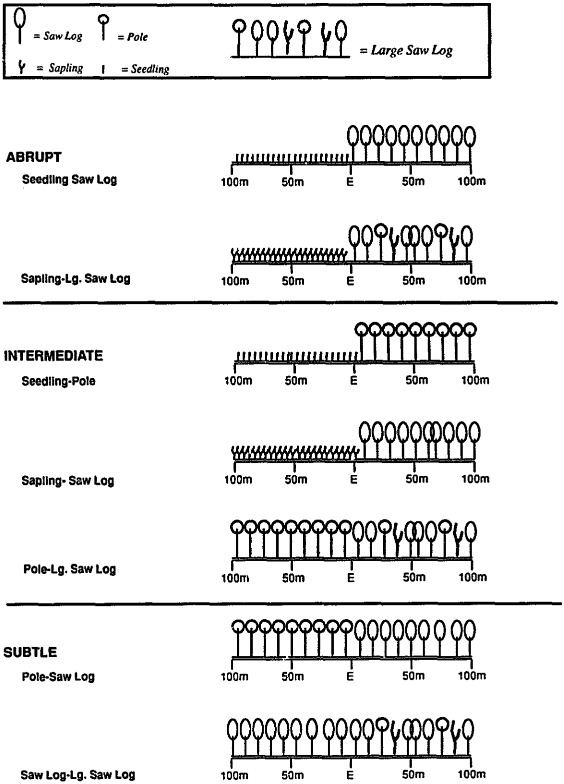


Fig. 1. Seven edge contrast types grouped into three classes; White Mountain National Forest, New Hampshire, U.S.A. Breeding birds counted at interfaces and 50, 100 m into each stand.

method of regeneration produces stands that, over time, represent various types of contrast: abrupt (seedling–sawlog, sapling–large sawlog), intermediate (seedling–pole, sapling–sawlog, pole–large sawlog) and subtle edges (pole–sawlog, sawlog–large sawlog). All stands in the present study were even-aged; the sawlog and large sawlog stands originated after extensive fires in the late 19th century. Younger stands resulted from clearcutting. Seedling and sapling stands were all 16 ha; pole, sawlog and large-sawlog stands ranged in area from 16 to 56 ha, with a mean of 25 ha.

Two edges of each type of contrast (14 edges, 28 stands) were sampled; birds were surveyed during June at the same locations 3 times in 1983 and 2 times yearly in 1984 and 1985. Surveys were conducted between 0500–0830 hours on clear, calm mornings at 5 points 50 m apart along transects across each edge. The center point was at the interface; points at 50 and 100 m extended into the stands to either side. Maximum clearcut size has been 16 ha for the past 20 years, so points more than 100 m from the edge of recent clearcuts are commonly within 150 m of the opposite side, depending upon the shape of the clearcut. Thus, transects were limited to a total length of 200 m. The order in which transects were surveyed was chosen randomly to evenly detect species that sang early or late in the sample period. The numbers of singing males of each species detected within 25 m of survey points were recorded during a 4-minute period to obtain relative abundances.

Woody vegetation was measured at the 50- and 100-m bird survey points in all stands. Numbers of stems of tree species in seedling and sapling stands were recorded on 4 circular 10 $m^2$ plots whose centers randomly clustered within 15 m of each bird census point. In pole, sawlog and large sawlog stands, species and diameter breast height (dbh) of all trees were recorded on 0.1-ha circular plots, and basal area (BA) was estimated using a 3-factor metric prism. The height of the canopy was estimated using a 3-m range pole.

Coefficients of similarity $S_s$ (Sorensen, 1948) were used to examine avian similarity between points at different distances from edge. Values range from 0 to 100 and are calculated as follows: $S_s = 2\,C\,/\,(A + B) \times 100$ where $C$ = the number of species occurring at both points (i.e. the number of shared species), and $A$ and $B$ = species richness at each respective point. As indices, these coefficients examine each pair of points for presence or absence of species, regardless of population, and express actual coinciding bird species counts as percents of possible coincidences. The closer $S_s$ is to 100, the more similar the bird species composition between points. Spatz's (1970) index was used to compare breeding birds across edge types grouped in 3 classes: abrupt, intermediate and subtle. Spatz's index, $RC/(A + B + C) \times 100$, where $R$ = the relative similarity of the 2 samples being compared, $C$ = the number of shared species, and $A$ and $B$ = species richness at the respective points, considers both the number of species and the relative abundance of each species; it is therefore more sensitive than Sorensen's (1948) to qualitative differences between points (Mueller-Dombois and Ellenberg, 1974:221). Analysis of variance (ANOVA) was used to test for differences in bird species richness and in numbers of bird species by territory size class. Differences among mean bird numbers grouped by foraging and nesting guilds were examined using the Kruskal–Wallis test (Conover, 1971).

## RESULTS

A total of 52 bird species (scientific names in Appendix I) were detected over 3 years. Four species were detected just once; 48 species were included in the analyses (Table 1). Of these, 28 species occurred on transects that crossed all 3 classes of edges. Three species occurred only on transects that crossed abrupt edges: pileated woodpecker, tree swallow, and Eastern bluebird. Six species — American woodcock, brown creeper, solitary vireo, northern parula, northern waterthrush, and purple finch — were not detected on transects that crossed abrupt edges. Three species were not detected on transects across subtle edges: cedar waxwing, mourning warbler, and American goldfinch (Table 1). No species occurred only at the interface (transect center point) between stands, but mean bird species richness was highest at the interface in 5 of the 7 edge contrast types (Table 2). Where young stands abutted, bird species richness showed a linear decline from the interior of seedling stands to the interior of pole stands (Table 3). Across edges between sawlog and large sawlog stands, mean species richness was highest in large sawlog stands; there were no differences in cumulative bird species richness values, either by edge contrast or by stand/edge distance (Table 3).

A comparison of species occurrences at stand interfaces and in adjacent stands showed that the proportion of species detected at a stand interface and also in both adjacent stands was lowest when the degree of edge contrast was highest. The proportion of interface-detected species was higher in the younger stand in all edge contrast types except the sawlog–large sawlog type (Table 4).

Conversely, edge "avoidance" as indicated by the proportion of bird species detected in both adjacent stands but not at the interface, was most pronounced when the stands were most different; values were high when sawlog stands abutted seedlings, when large sawlogs abutted saplings or poles, and when seedlings abutted poles (Table 4).

Along transects that crossed pole–sawlog and sawlog–large sawlog edges,

TABLE 1

Mean (SD) values of stand characteristics in 28 even-aged northern hardwood stands, White Mountain National Forest, New Hampshire, 1983

| | Seedlings $n = 4$ | Saplings $n = 4$ | Poles $n = 6$ | Sawlogs $n = 8$ | Large Sawlogs $n = 6$ |
|---|---|---|---|---|---|
| Basal area, $m^2$/ha | | 13.1 (2.8) | 22.9 (1.9) | 26.7 (3.1) | 31.9 (3.2) |
| Dbh, cm | <2.5 | 6.4 (1.2) | 19.3 (1.9) | 25.0 (3.0) | 40.2 (5.6) |
| Density, 1000 stems/ha | 28.8 (5.4) | 8.6 (2.1) | 1.3 (0.4) | 0.7 (0.3) | 0.6 (0.2) |
| Canopy height, m | 2.3 (0.4) | 8.2 (0.9) | 29.8 (2.9) | 31.8 (3.9) | 32.6 (3.8) |

TABLE 2

Number of detections[a] of breeding birds along transects across three classes of forest edges between even-aged northern hardwoods, White Mountain National Forest, New Hampshire, 1983–1985

| Species | Foraging Guild[c] | Nesting Guild[d] | Territory Size-class[e] | Forest edge class[b] Abrupt | | | Intermediate | | | Subtle | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 100y[f] | E[g] | 10o[h] | 100y | E | 100o | 100y | E | 100o |
| Ruffed Grouse | G | G | 4 | 0.06 | 0.08 | | 0.07 | 0.13 | 0.04 | 0.14 | 0.06 | |
| American woodcock | G | G | 4 | | | | | | | | 0.06 | |
| Ruby-throated hummingbird | F | B | 1 | 0.17 | 0.08 | | 0.30 | 0.04 | | 0.11 | | |
| Northern flicker | B | C | 3 | | 0.08 | | | 0.04 | | 0.06 | 0.06 | |
| Pileated woodpecker | B | C | 4 | | | 0.06 | | | | | | |
| Yellow-bellied sapsucker | B | C | 4 | | 0.11 | 0.08 | | | | | 0.19 | 0.28 |
| Hairy woodpecker | B | C | 4 | | | 0.17 | | | 0.04 | 0.14 | | 0.11 |
| Downy woodpecker | B | C | 3 | | 0.25 | | 0.06 | | 0.06 | 0.08 | 0.08 | 0.14 |
| Willow flycatcher | A | B | 2 | 0.67 | 0.14 | | 0.28 | | | | | |
| Least flycatcher | A | B | 1 | | 0.39 | 0.19 | | 0.19 | | 0.33 | 0.56 | 0.78 |
| Eastern wood-peewee | A | T | 4 | | 0.50 | 0.11 | | 0.13 | | | 0.06 | 0.06 |
| Tree swallow | A | C | 1 | 0.81 | | | | | | | | |
| Blue jay | G | B | 3 | | 0.08 | | | | | 0.08 | 0.08 | 0.17 |
| Black-capped chickadee | C | C | 4 | | 0.08 | 0.08 | | | | | | 0.06 |
| White-breasted nuthatch | B | C | 4 | | 0.08 | 0.06 | 0.09 | 0.06 | 0.04 | 0.08 | 0.08 | |
| Brown creeper | B | C | 4 | | | | | | | | 0.14 | |
| Winter wren | G | G | 3 | 0.11 | 0.17 | 0.22 | | 0.09 | 0.13 | 0.08 | 0.44 | 0.67 |
| Gray catbird | G | S | 1 | | | | 0.17 | | | | | |
| American robin | G | B | 1 | | 0.08 | | 0.06 | 0.06 | 0.06 | 0.06 | 0.33 | 0.25 |

TABLE 2 (Cont'd.)

| Species | Foraging Guild[c] | Nesting Guild[d] | Territory Size-class[e] | Forest edge class[b] Abrupt | | | Intermediate | | | Subtle | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 100y[f] | E[g] | 10o[h] | 100y | E | 100o | 100y | E | 100o |
| Wood thrush | G | B | 2 | | | 0.28 | 0.31 | 0.30 | 0.33 | 0.69 | 0.69 | 0.53 |
| Hermit thrush | G | G | 2 | | 0.17 | 0.14 | | 0.04 | 0.04 | 0.14 | 0.14 | 0.39 |
| Swainson's thrush | G | B | 2 | 0.50 | 0.31 | 0.08 | 0.54 | 0.52 | 0.13 | 0.25 | 0.28 | 0.44 |
| Veery | G | G | 1 | 0.06 | | | 0.48 | 0.35 | 0.31 | 0.92 | 0.22 | 0.31 |
| Eastern bluebird | G | C | 4 | 0.06 | | | | | | | | |
| Cedar waxwing | A | B | 2 | 0.44 | | | 0.19 | | | | | |
| Solitary vireo | C | B | 2 | | | | | | 0.04 | | 0.17 | 0.11 |
| Red-eyed vireo | C | S | 2 | 0.39 | 0.94 | 1.19 | 0.98 | 1.11 | 1.15 | 1.22 | 1.25 | 1.19 |
| Philadelphia vireo | C | T | 2 | 0.25 | 0.81 | | 0.04 | 0.20 | 0.11 | 0.06 | 0.06 | |
| Black-and-white-warbler | B | G | 1 | 0.28 | 0.14 | 0.22 | 0.28 | 0.33 | 0.09 | 0.14 | 0.44 | 0.06 |
| Nashville warbler | LC | G | 1 | 0.06 | 0.06 | | | 0.06 | 0.04 | 0.06 | 0.17 | |
| Northern parula | C | T | 1 | | | | | | | | 0.08 | 0.17 |
| Black-throated blue warbler | LC | S | 1 | | 0.53 | 1.11 | 0.11 | 0.24 | 0.48 | 0.47 | 0.33 | 1.08 |
| Yellow-rumped warbler | C | B | 1 | | | 0.06 | 0.04 | | | | | 0.06 |
| Black-throated green warbler | C | B | 2 | 0.06 | | 0.56 | 0.17 | 0.30 | 0.67 | 0.50 | 0.33 | 0.75 |
| Blackburnian warbler | C | T | 1 | | 0.06 | 0.08 | | 0.04 | 0.06 | 0.06 | 0.19 | 0.17 |
| Chestnut-sided warbler | LC | S | 3 | 1.81 | 0.94 | | 1.43 | 1.06 | 0.04 | 0.17 | 0.14 | |
| Ovenbird | G | G | 3 | | 0.06 | 1.31 | 0.26 | 0.69 | 0.21 | 1.25 | 1.11 | 1.61 |
| Northern waterthrush | G | G | 1 | | | | | | | | | 0.06 |
| Mourning warbler | G | G | 2 | 0.97 | 0.89 | | 0.24 | .07 | | | | |
| Common yellowthroat | LC | G | 2 | 1.33 | 1.14 | | 0.85 | 0.43 | | 0.31 | 0.08 | |

TABLE 2 (Cont'd.)

| Species | Foraging Guild[c] | Nesting Guild[d] | Territory Size-class[e] | Forest edge class[b] | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Abrupt | | | Intermediate | | | Subtle | | |
| | | | | 100y[f] | E[g] | 10o[h] | 100y | E | 100o | 100y | E | 100o |
| Canada warbler | LC | G | 1 | 0.11 | 0.11 | | 0.15 | 0.09 | 0.04 | 0.17 | 0.17 | |
| American redstart | A | B | 1 | 0.67 | 1.36 | 0.75 | 1.48 | 1.19 | 0.74 | 1.17 | 0.56 | 1.00 |
| Scarlet tanager | C | T | 2 | | 0.11 | 0.36 | | 0.04 | 0.24 | 0.17 | 0.25 | 0.42 |
| Rose-breasted grosbeak | C | B | 2 | 0.64 | 0.44 | 0.11 | 0.76 | 0.70 | 0.59 | 0.47 | 0.53 | 0.31 |
| Purple finch | C | B | 4 | | | | | | | | 0.08 | |
| American goldfinch | G | T | 4 | 0.06 | | | 0.11 | | | | | |
| Dark-eyed junco | G | G | 4 | 0.31 | 0.08 | 0.17 | | 0.04 | | | 0.17 | 0.08 |
| White-throated sparrow | G | G | 2 | 1.72 | 1.39 | | 1.02 | 0.65 | | 0.11 | 0.06 | |
| Total | | | | 11.50 | 11.69 | 7.39 | 10.48 | 9.15 | 6.26 | 9.47 | 9.72 | 11.22 |

[a]Highest number of detections per point averaged over 3 years after Robbins et al. (1989); birds were counted 3 times in 1983 and twice yearly in 1984 and 1985. Four species were each detected once and were not included in the analyses: evening grosbeak,, golden-crowned kinglet,, broad-winged hawk,, and song sparrow.

[b]Abrupt: seedling–sawlog, sapling–lg. sawlog; Intermediate: seedling–pole, sapling–sawlog, pole–lg. sawlog; Subtle: pole–sawlog, sawlog–lg. sawlog.

[c]Foraging guilds: A = air, B = bark, C = canopy, LC = lower canopy, G = ground (after DeGraaf and Chadwick, 1984).

[d]Nesting guild: B = tree branch, C = cavity, G = ground, S = shrub vine/bramble, T = tree twig (after DeGraaf and Chadwick, 1984).

[e]Territory size-class (ha): 1 = <0.5, 2 = 0.5–1.0, 3 = 1.0–2.0, 4 = >2.0.

[f,g,h]Points 100 m from the interface (g) of younger (f) and older (h) stands; points 100 y and 100o are 200 m apart.

TABLE 3

Cumulative and mean (SD) yearly bird species richness along transects across 7 northern hardwood edge types, White Mountain National Forest, New Hampshire, during June, 1983–1985

| | Bird Species Richness | | | | |
|---|---|---|---|---|---|
| | Younger stand - distance (m) from interface - older stand | | | | |
| Edge class and type | 100 | 50 | Edge | 50 | 100 |
| Abrupt | | | | | |
| Seedling–Sawlog | 21,13.3(2.5) | 18,10.3(0.6) | 26,15.0(3.0) | 20,10.7(5.5) | 17,10.0(2.0) |
| Sapling–L.Sawlog | 16,9.7(4.0) | 16,9.0(1.0) | 21,11.7(4.9) | 17,9.3(4.9) | 15,8.3(4.9) |
| Intermediate | | | | | |
| Seedling–Pole | 19,13.3(2.1) | 21,13.0(3.5) | 17,10.0(2.0) | 13,7.7(4.7) | 15,7.2(4.0) |
| Sapling–Sawlog | 18,11.7(2.1) | 19,11.3(4.9) | 24,15.3(6.1) | 17,9.7(4.5) | 16,9.3(5.0) |
| Pole–L.Sawlog | 14,8.3(0.6) | 12,7.3(2.3) | 16,9.7(4.6) | 13,7.7(1.5) | 13,7.3(2.5) |
| Subtle | | | | | |
| Pole–Sawlog | 19,10.3(5.9) | 20,12.3(2.5) | 28,14.3(5.9) | 20,12.3(3.1) | 23,12.7(4.0) |
| Sawlog–L.Sawlog | 22,12.7(4.7) | 18,11.3(4.9) | 23,13.3(2.1) | 22,12.0(5.3) | 23,14.3(4.2) |

all similarity ($S_s$) values were ≥ 60 — all bird species assemblages were clearly more similar than different for all points of comparison (Table 5). Along transects that crossed seedling–pole, sapling–sawlog, and pole–large sawlog edges, all similarity ($S_s$) values were ≥ 50 — bird species assemblages were generally more similar than different. Only across seedling–sawlog and sapling–large sawlog edges were bird assemblages more different than similar, and, as expected, were most dissimilar at sample points that were most distant from one another.

The juxtaposition of saplings and large sawlogs produced the most dissimilar ($S_s$ = 19) bird assemblages among all edge types compared. But the dissimilarity in bird species assemblages across sapling–large sawlog edges was much lower along pole–large sawlog edges (Tables 4, 5). The most similar bird assemblages occurred at pole–sawlog edges. The breeding bird assemblage at the edge is clearly more similar to that in the younger stand across seedling–sawlog and sapling–sawlog edges. Across pole–sawlog and pole–large sawlog edges, the edge assemblages were similar to those in both adjacent stands (Table 5).

Regarding width of edge, breeding bird assemblages 50 and 100 m from the edge are in all cases more similar to (all $S_s$ ≥ 50) than different from those at stand interfaces (Table 5). Edges between seedling or sapling stands and sawlog stands begin to separate dissimilar avian assemblages at points 100 m apart (i.e. 50 m into each stand) (Table 5).

TABLE 4

Number of breeding bird species at the interface and in adjacent northern hardwood stands, White Mountain National Forest, New Hampshire, 1983–1985

| Edge type | Total | In both stands | At interface and >25 m in younger stand | At interface and >25 m in older stand | In each stand but not at interface | |
|---|---|---|---|---|---|---|
| Seedling–Pole | 17 | 11 | 15 | 13 | Seedling:9 | Pole:4 |
| Seedling–Sawlog | 26 | 9 | 17 | 15 | Seedling:6 | Sawlog:9 |
| Sapling–Sawlog | 24 | 12 | 19 | 14 | Sapling:4 | Sawlog:5 |
| Sapling–Lg. Sawlog | 21 | 12 | 11 | 11 | Sapling:7 | Lg.Sawlog:8 |
| Pole–Sawlog | 28 | 17 | 21 | 20 | Pole:1 | Sawlog:5 |
| Pole–Lg. Sawlog | 16 | 8 | 12 | 11 | Pole:4 | Lg.Sawlog:7 |
| Sawlog–Lg. Sawlog | 23 | 15 | 16 | 21 | Sawlog:8 | Lg.Sawlog:7 |

TABLE 5

Avian similiarity ($S_s$) between points at 50 m and 100 m from the interface in adjacent stands for 7 edge types in even-aged northern hardwoods, White Mountain National Forest, 1983–85

| Edge type | Comparisons among younger (y) and older (o) stands using points 100 m and 50 m from interface (E) | | | | | |
|---|---|---|---|---|---|---|
| | 100y,E | 50y,E | 50o,E | 100o,E | 50y,50o | 100y,100o |
| Seedling–sawlog | 64 | 64 | 52 | 51 | 37 | 32 |
| Sapling–sawlog | 76 | 79 | 60 | 58 | 50 | 53 |
| Sapling–L. sawlog | 54 | 65 | 53 | 56 | 36 | 19 |
| Seedling–pole | 72 | 74 | 73 | 75 | 53 | 53 |
| Pole–L. sawlog | 73 | 71 | 62 | 62 | 50 | 52 |
| Pole–sawlog | 81 | 79 | 71 | 75 | 60 | 62 |
| Sawlog–L. sawlog | 67 | 68 | 76 | 78 | 75 | 67 |

Species similarity across northern hardwood edges generally increased as stands adjacent to large sawlogs matured: a comparison of indices at 50 and 100 m from the edge showed that sapling–large sawlog < pole–large sawlog < sawlog–large sawlog (Table 5). Thus, the less the age/height contrast between even-aged northern hardwood stands, the more similar the breeding bird species composition across the edge.

Spatz's (1970) similarity index, which considers both the number of species and the number of individuals within each species, yielded similarity indices of 3, 20, and 25, respectively, for bird detections across abrupt, intermediate, and subtle edges at points 100 m from the edge in the younger and older stands. Sorensen's index, which uses only numbers of species, yielded values of 22, 50, and 51, respectively for abrupt, intermediate, and subtle edges.

Differences in the number of bird species by territory size–class within and among edge contrast types were examined by ANOVA. Birds were placed in territory size-classes ($\leq$ 0.5, 0.5–1.0, 1.1–2.0, > 2.0 ha) based upon sizes reported in the literature and summarized by DeGraaf and Rudis (1986). A 3-way ANOVA testing the number of species by territory size-class, edge contrast type, and year showed no significant effects.

A 4-way ANOVA using edge type, distance from edge, and territory size-class as fixed effects and year as a random effect was used to test main classifications, all possible 2-way interactions, and the interactions of edge type, distance from edge, and territory size-class. The error contained all 4-way interactions and all 3-way interactions involving year. The interactions of year and edge and of year and distance were not significant ($P > 0.05$), so these sources of variation were added to the residuals. $F$-tests then showed that territory size and distance from edge by territory size were different ($P < 0.01$). Species with small territories were more numerous than those with large territories, and they tended to be more abundant in the "younger" side of an edge, i.e. where seedlings and saplings abutted older stands. Older stands, on the other hand, contained more species with larger territory sizes in all edge types except those between seedling-pole stands (Table 2).

The distributions of bird detections by foraging and nesting guilds differed significantly ($P < 0.05$) only when seedling or sapling stands abutted stands that were pole-sized or larger, respectively (Table 6). Ground foragers and low canopy gleaners, and ground-nesting and shrub-nesting birds were the only guilds that differed in distribution across edges, and in all cases, greater numbers occurred on the "younger" side of the edge.

## DISCUSSION

No unique breeding bird assemblages were evident at edges between even-aged stands of northern hardwoods. Edges between New England northern hardwood stands, even of greatly contrasting age or height, are different from field–forest edges, which generally support different communities of vertebrates than those within the habitats to either side.

Differences in breeding bird assemblages across edges between even-aged stands of New England northern hardwoods do not persist long after clearcutting. There are essentially no differences in foliage profiles among northern hardwood stands that are more than 30 years old (Aber, 1979). Foliage profiles in stands of widely disparate ages are similar because northern hardwood species reach their maximum height of about 26 m fairly early in the life of the stand. Also, short trees of shade-tolerant species will persist in the understory

TABLE 6

Mean (SD) detections[a] of breeding birds by foraging and nesting guilds that differed[b] among distances from northern hardwood stand interfaces, White Mountain National Forest, New Hampshire, 1983–1985.

| | Edge type | Younger stand — distance from interface — older stand | | | | |
|---|---|---|---|---|---|---|
| | | 100 m | 50 m | E | 50 m | 100 m |
| Foraging Guild | | | | | | |
| Low canopy | seedling–pole | 3.39 (1.14) | 3.83 (0.76) | 2.56 (1.09) | 1.00 (0.50) | 0.61 (0.67) |
| Ground | seedling–sawlog | 4.87 (0.81) | 3.72 (0.86) | 4.17 (1.04 | 1.83 (0.29) | 1.94 (0.82) |
| Low canopy | seedling–sawlog | 3.72 (0.86) | 3.78 (1.11) | 3.89 (1.21) | 1.33 (0.76) | 1.22 (0.39) |
| Low canopy | sapling–sawlog | 2.94 (0.59) | 2.89 (0.84) | 2.39 (0.79) | 0.77 (0.64) | 0.56 (0.10) |
| Low canopy | sapling–l. sawlog | 2.89 (0.68) | 3.22 (1.07) | 1.67 (0.58) | 0.94 (0.42) | 1.00 (0.00) |
| Nesting Guild | | | | | | |
| Shrub | seedling–pole | 3.89 (0.54) | 2.89 (0.54) | 2.44 (0.77) | 1.61 (0.35) | 1.39 (0.35) |
| Ground | seedling–sawlog | 6.56 (1.90) | 5.22 (1.35) | 5.50 (1.50) | 2.22 (0.63) | 2.11 (0.19) |
| Ground | sapling–l. sawlog | 3.44 (1.00) | 3.50 (0.87) | 3.11 (1.02) | 1.72 (0.25) | 2.00 (0.50) |

[a]Highest count per distance from interface per day averaged over 3 years (after Robbins et al., 1989).
[b]Significant difference ($P < 0.05$) among means, Kruskal–Wallis test (Conover, 1971).

even after the canopy closes. This likely accounts for the similarities of breeding bird assemblages across stand edges that are beyond the "abrupt" stage — seedling–sawlog or sapling–large sawlog.

Occurrence of avian foraging and nesting guilds across stand edges only differed when seedling or sapling stands abutted older stands. Northern hardwoods generally reach pole-timber size (mean dbh > 10 cm) within 25–35 years after clearcutting in New England (Leak et al., 1987); the breeding bird assemblages in such stands can be expected to soon become similar to those in adjacent older stands in areas of extensive forest.

These results apply to small forest birds, especially passerines. The distribution of raptors and other species with large home ranges are likely less affected in their habitat use by edges between even-aged stands when maximum clearcut sizes are < 16 ha, as is the case where this study was conducted.

Kroodsma (1984) found no edge effect (increase in relative density) at forest-corridor edges in eastern Tennessee and argued that an increase in powerline corridor width rendered singing-post trees at the edge less available to males of 5 passerine species; as the frequency of vegetation > 2 m in height in the corridor increased, males sang proportionally more often from the corridor interior.

Passerines showed no consistent edge effect at abrupt forest–river and forest–powerline edges in Maine (Small and Hunter, 1989). Forest vegetation was similar at edges, but different bird species occupied the two edge types. Species needing brush or shrubs were found at powerline edges but not at river edges.

Studies in several areas have reported greater densities of birds at abrupt clearcut edges than in forest interior: Florida (McElveen, 1979), Texas (Strelke and Dickson, 1980) and Sweden (Hansson, 1983). The degree of permanence of the open habitat, hence the nature of the edge, may be important. Where clearcuts regenerate slowly or develop a grass/shrub cover, an edge effect may occur.

The lack of a unique edge community in the present study is likely due to the extensive forest cover in the region and the rapidity with which clearcuts regenerate. Woody stem densities of 175,000/ha are common the second growing season after clearcutting (Marquis, 1967). Clearcuts do not develop a grass or herb stage nor a brushy border. Thus, typical New England edge species such as American kestrel, northern mockingbird, northern cardinal, rufous-sided towhee, chipping sparrow, and field sparrow were not detected during this study, and song sparrow and gray catbird were only detected a few times. Clearcuts in New England northern hardwoods regenerate so quickly that their edges are ephemeral, and brushy edges do not develop.

In regions of extensive northern hardwood forest, edges between stands do not constitute distinct avian habitats. Each even-aged timber size-class supports a distinct avian community, and edges between them can be treated as lines rather than areas in forest planning.

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## APPENDIX I

Scientific names of birds occurring in New England northern hardwoods

American Kestrel (*Falco sparverius*)
Ruffed Grouse (*Bonasa umbellus*)
American Woodcock (*Scolopax minor*)
Ruby-throated Hummingbird (*Archilochus colubris*)
Yellow-bellied Sapsucker (*Sphyrapicus varius*)
Downy Woodpecker (*Picoides pubescens*)
Hairy Woodpecker (*Picoides villosus*)
Northern Flicker (*Colaptes auratus*)
Pileated Woodpecker (*Dryocopus pileatus*)
Eastern Wood-Peewee (*Contopus virens*)
Willow Flycatcher (*Empidonax traillii*)
Least Flycatcher (*Empidonax minimus*)
Tree Swallow (*Tachycineta bicolor*)
Blue Jay (*Cyanocitta cristata*)
Black-capped Chickadee (*Parus atricapillus*)
White-breasted Nuthatch (*Sitta carolinensis*)
Brown Creeper (*Certhia americana*)
Winter Wren (*Troglodytes troglodytes*)
Eastern Bluebird (*Sialia sialis*)
Veery (*Catharus fuscescens*)
Swainson's Thrush (*Catharus ustulatus*)
Hermit Thrush (*Catharus guttatus*)
Wood Thrush (*Hylocichla mustelina*)
American Robin (*Turdus migratorius*)
Gray Catbird (*Dumetella carolinensis*)
Northern Mockingbird (*Mimus polyglottos*)
Cedar Waxwing (*Bombycilla cedrorum*)
Solitary Vireo (*Vireo solitarius*)
Philadelphia Vireo (*Vireo philadelphicus*)
Red-eyed Vireo (*Vireo olivaceus*)
Nashville Warbler (*Vermivora ruficapilla*)
Northern Parula (*Parula americana*)
Chestnut-sided Warbler (*Dendroica pensylvanica*)
Black-throated Blue Warbler (*Dendroica caerulescens*)
Yellow-rumped Warbler (*Dendroica coronata*)
Black-throated Green Warbler (*Dendroica virens*)
Blackburnian Warbler (*Dendroica fusca*)
Black-and-white Warbler (*Mniotilta varia*)
American Redstart (*Setophaga ruticilla*)
Ovenbird (*Seiurus aurocapillus*)
Northern Waterthrush (*Seiurus noveboracensis*)
Mourning Warbler (*Oporornis philadelphia*)
Common Yellowthroat (*Geothlypis trichas*)
Canada Warbler (*Wilsonia canadensis*)
Scarlet Tanager (*Piranga olivacea*)
Northern Cardinal (*Cardinalis cardinalis*)
Rose-breasted Grosbeak (*Pheucticus ludovicianus*)

Rufous-sided Towhee (*Pipilo erythrophthalmus*)
Chipping Sparrow (*Spizella passerina*)
Field Sparrow (*Spizella pusilla*)
White-throated Sparrow (*Zonotrichia albicollis*)
Dark-eyed Junco (*Junco hyemalis*)
Purple Finch (*Carpodacus purpureus*)
American Goldfinch (*Carduelis tristis*)