EFFECTS OF SILVICULTURAL PRACTICES ON BIRD COMMUNITIES IN UPLAND SPRUCE-FIR STANDS

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Abstract.--Composition and density of bird populations in upland spruce-fir stands are influenced by the admixture of hardwood with softwoods, the vertical and horizontal structure of the stand, and the extent of spruce budworm infestation of the stand. Silvicultural practices modify all three factors and influence bird populations.

INTRODUCTION

Upland spruce-fir forest types in northeastern and north-central United States and Maritime and southern Canada are largely commercial forests, supporting major wood-using industries. In the United States, most of this forest land is privately owned; in Canada, there is more public ownership. However, in both cases, forest cutting is a major factor that modifies bird habitat structure and influences bird populations.

These commercial woodlands provide the economic base for several states and provinces. Yet the management of these forests is not intensive compared to that in other parts of the continent. Woodland owners and harvesters had enough wood to cut to meet yesterday's needs. However, the situation is beginning to change.

The demand for wood products continues to increase. In the past, industry had the western old-growth forests and the "wood basket" of the South to absorb this demand. Substantial inroads have been made on the old growth and the wood basket is not as deep or productive as once thought. These factors plus competition among the major wood-producing companies will bring intensive forestry to the northern and northeastern coniferous forests, and these practices will have a measurable impact on bird populations.

This paper discusses the effects of silvicultural practices on nongame birds in upland spruce-fir forests.

The major tree species of the upland spruce-fir type are balsam fir (*Abies balsamea*), white spruce (*Picea glauca*), and red spruce (*P. rubens*). Red spruce is limited to eastern portions of the continent, but white spruce is found westward across the continent and balsam fir beyond midcontinent. The transcontinental belt of spruce and fir averages about 300 miles wide (Westveld 1953). Red spruce and balsam fir also grow southward in the higher elevations of the Appalachian Mountains. In West Virginia, balsam fir possibly intergrades with Fraser fir (*A. fraseri*) (Strausbaugh and Core 1964).

Spruce and fir along the northern border of their transcontinental belt are often found in almost pure stands. Intolerant hardwoods such as the birches (*Betula* spp.) and aspens (*Populus* spp.) increase toward the central latitudinal portion of this belt. Along the southern border, midtolerant and tolerant hardwoods such as beech (*Fagus grandifolia*) and maples (*Acer* spp.) compete with spruce and fir for favorable sites.

Although hardwoods are naturally more abundant in the southern portion of the upland spruce-fir type, site characteristics substantially influence their distribution and abundance. Spruce and fir on thin, infertile soils in the moist eastern portion of the range generally grow in dense stands with closed canopies and little hardwood admixture. In an undisturbed state these stands

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are single-storied with sparse undergrowth. More fertile soils permit more hardwood growth and increased canopy layering. In the more continental climate to the west, hardwoods are better competitors for limited soil moisture, and moisture stress increases the mixture of hardwoods in spruce-fir stands (Westveld 1953).

BREEDING BIRD COMMUNITIES

The composition and density of bird communities throughout the upland spruce-fir forest are affected by three habitat features: the degree of hardwood admixture with softwoods, the vertical and horizontal stand structure, and the degree of spruce budworm (*Choristoneura fumiferana* Clem.) infestation in the stands. These features can vary considerably from forest stand to forest stand. We also recognize there can be fluctuations in density of bird populations from year to year caused by factors such as winter mortality, migration losses, etc.

The first two features depend on such factors as geographic location, microclimate, site characteristics, and forest management. Spruce budworm infestations appear to be cyclic in nature and are affected by weather and the amount, age, and distribution of balsam fir in the stand.

To describe the relationship between bird populations and forest habitats we analyzed census data from 16 forest stands representing different conditions in upland conifers (Table 1). Cluster analysis was used to express the degree of association or similarity between the bird populations of the 16 stands. We placed each of the 16 bird censuses into one of six groups based on the similarity of their bird species composition (Fig. 1, Table 2):

- Balsam fir stands (censuses 1 and 2)
- Mature spruce stands (censuses 5,6,7,8, and 9)
- Mixed growth stands (censuses 14,15, and 16)
- Spruce-fir stands with budworm (censuses 3 and 4)
- Spruce-fir stands without budworm (censuses 12 and 13)
- Young spruce stands (censuses 10 and 11)

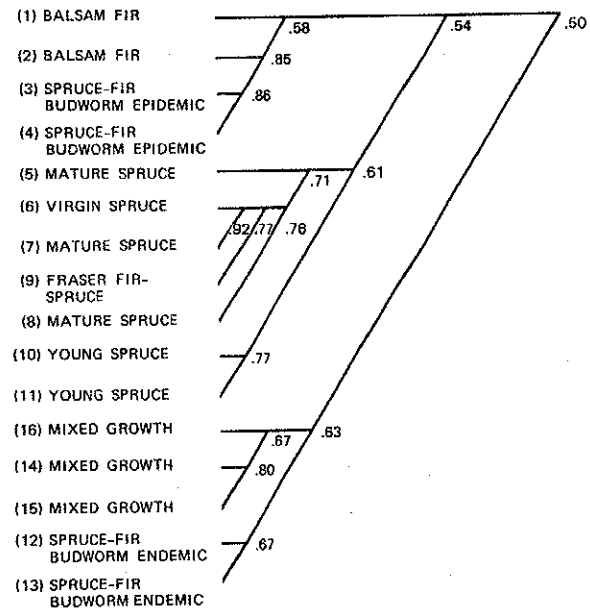

Figure 1.--Cluster diagram of forest plots based on bird species composition. Similarity indices are shown at connecting points.

Balsam Fir Stands

In the two balsam fir stands, this species dominated the overstory trees. The stand located near Lake Winnipegosis, Manitoba (Erskine 1972), was characterized by a two-tier overstory with a dominant canopy (about 17 m tall) of fir and paper birch and a subcanopy (about 9.5 m tall) of fir, birch, and quaking aspen (*P. tremuloides*). The stand located in west-central Saskatchewan (Erskine 1973) was characterized by dense, immature growth of balsam fir (9 to 12 m tall) and small numbers of mature fir, spruce, aspen, and birch scattered throughout (up to 25 m tall).

The balsam fir stands supported an impoverished avifauna with an average of only 128 pairs/40 ha and 20 bird species. The four dominant bird species were the Swainson's thrush (*Catharus ustulata*) and magnolia (*Dendroica magnolia*), black-throated green (*D. virens*), and bay-breasted (*D. castanea*) warblers. The Swainson's thrush and magnolia warbler were associated with the immature balsam fir.

Qualitatively, the two balsam fir stands were similar in bird species composition to the budworm infested spruce-fir stands (Table 2). The presence of Tennessee (*Vermivora peregrina*) and bay-breasted warblers, species closely associated with spruce budworm, was probably a result of spruce budworm populations.

Table 1.--Summary of bird censuses used in analyses of bird communities in upland conifers

Census no.	Forest type	Location	No. of species	Pr/ 40 ha	Source
1	Balsam fir forest	Manitoba	20	112	Erskine (1972)
2	Balsam fir forest	Saskatchewan	19	145	Erskine (1973)
3	Spruce-fir forest budworm epidemic	Ontario	36	319	Kendeigh (1947)
4	Spruce-fir forest budworm epidemic	Maine	31	350	Stewart and Aldrich (1952)
5	Mature 2nd-growth spruce	New Hampshire	21	235	Titterington (Unpubl. data)
6	Virgin spruce forest	West Virginia	28	325	Stewart and Aldrich (1949)
7	Mature 2nd-growth spruce	West Virginia	23	295	Stewart and Aldrich (1949)
8	Mature red spruce forest	Vermont	20	217	Nichols (1968)
9	Mature Fraser fir-spruce	West Virginia	23	247	Hutton et al. (1968)
10	Young spruce	West Virginia	19	278	Stewart and Aldrich (1949)
11	Young spruce	West Virginia	15	220	Sigel et al. (1968)
12	Spruce-fir forest budworm endemic	Ontario	24	249	Martin (1960)
13	Spruce-fir forest budworm endemic	Ontario	28	131	Sanders (1970)
14	Spruce-fir-aspen-birch, mixed growth	Ontario	22	159	Martin (1960)
15	Spruce-fir-hardwood, mixed growth	Ontario	27	258	Martin (1960)
16	Balsam fir-birch forest, mixed growth	Minnesota	23	276	Niemi (1972)

Mature Spruce-Fir with Epidemic Spruce Budworm Populations

Dominant spruce and fir with overmature and dying trees, a midstory of balsam fir, and an open shrub understory botanically characterized these stands (Kendeigh 1947, Stewart and Aldrich 1952). The characteristic biological features were an ongoing spruce budworm infestation and high densities of breeding birds (Morris et al. 1958). The budworm areas supported 1.75 times as many pairs/40 ha as similar stands with endemic budworm populations (334 pairs/40 ha compared to 190/40 ha). Three warbler species, the Tennessee, Cape May (*D. tigrina*) and bay-breasted, were abundant in the budworm areas but absent from non-budworm areas (Table 2). These three species show strong positive numerical responses to spruce budworm outbreaks (Morris et al. 1958).

Spruce-Fir with Endemic Spruce Budworm Populations

Balsam fir predominated in these stands and white and black (*P. mariana*) spruce also were significant in the overstory. The overstory had a clumped distribution with several shrub species occupying the openings. Sanders (1970) found intolerant hardwoods in the overstory but Martin (1960) did not. Average heights of overstory trees were about 10 and 15 m in Sanders' and Martin's areas, respectively.

The magnolia warbler was the dominant species; yellow-rumped warblers (*D. coronata*) and golden-crowned kinglets (*Regulus satrapa*) were abundant in the overstory canopy. White-throated sparrows (*Zonotrichia albicolis*) and chestnut-sided warblers (*D. pensylvanica*), both common species, were found in the shrubby openings.

Table 2.--Density of bird populations, by species and forest type (in pairs per 40 ha: o = absent; + = <5; * = 5 to 10; ** = 11 to 25; *** = >25)

Species	Balsam fir	Mature spruce	Mixed growth	Budworm spruce-fir	Non-budworm spruce-fir	Young spruce 15-30 ft tall
Yellow-bellied sapsucker	o	o	*	+	+	o
Black-capped chickadee	o	+	*	+	+	*
Boreal chickadee	+	+	o	*	+	+
Red-breasted nuthatch	+	*	+	*	+	*
Brown creeper	o	+	o	+	o	o
Winter wren	*	+	+	+	+	**
American robin	o	+	+	+	+	**
Wood thrush	o	+	+	o	o	o
Hermit thrush	o	*	+	+	+	+
Swainson's thrush	**	*	+	**	+	**
Veery	o	+	*	+	o	+
Golden-crowned kinglet	o	***	+	*	**	*
Solitary vireo	+	**	o	*	o	o
Red-eyed vireo	+	+	***	*	+	o
Black-and-white warbler	o	o	**	o	*	o
Tennessee warbler	*	o	o	***	o	o
Nashville warbler	o	o	**	*	*	o
Magnolia warbler	**	***	**	***	***	***
Black-throated blue warbler	o	**	+	+	o	o
Cape May warbler	o	o	o	***	o	o
Yellow-rumped warbler	*	*	+	**	**	o
Black-throated green warbler	**	**	*	+	o	+
Blackburnian warbler	+	***	**	**	+	+
Chestnut-sided warbler	o	o	*	o	**	+
Bay-breasted warbler	**	o	o	***	o	o
Ovenbird	+	+	***	*	*	o
Canada warbler	*	*	**	+	o	o
Purple finch	o	*	+	+	+	*
Dark-eyed junco	o	***	o	*	+	***
White-throated sparrow	*	*	*	**	***	o
$\bar{X}$ pairs/40 ha	128	264	231	334	190	249
$\bar{X}$ species	20	23	24	34	26	17

Mature Spruce

The mature spruce stands were second growth except for one virgin stand with a considerable tolerant hardwood component. The virgin stand (Stewart and Aldrich 1949) was essentially one-storied with a sparse scattering of understory trees and shrubs. Second-growth stands were mature and contained large trees, dense closed canopies, and scattered openings with shrubs and saplings. The canopy of one stand (Hutton et al. 1968) was nearly 50 percent Fraser fir and 35 percent red spruce. Canopies in the other stands were 60 to 90 percent red spruce (Stewart and Aldrich 1949, Nichols 1968, Titterington unpubl. data). The Fraser fir stand grouped with mature spruce because the fir were unusually large trees--up to 48 cm dbh. Few balsam fir reach this size and tree size seems to be a determinant in bird populations.

These stands supported almost as many birds as the budworm-infested stands. The most abundant birds were the canopy gleaners--blackburnian warbler (*D. fusca*) and golden-crowned kinglet in the upper canopy; solitary vireo (*Vireo solitarius*), magnolia, black-throated blue (*D. caerulescens*) and black-throated green warblers in the mid- to lower canopy; and dark-eyed junco (*Junco hyemalis*) on the open forest floor. The mature spruce stands supported more than twice as many birds as the balsam fir stands, an average of 264 pairs/40 ha compared to 128 for balsam fir. Several factors may account for this substantial difference. Spruce are long lived, commonly grow taller (USDA 1965), and develop greater canopy depth than balsam fir. Spruce express dominance and provide more heterogeneous horizontal and vertical stand structure than is found in fir stands. We believe spruce stands with more foliage and limb area than fir stands support greater populations of endemic insects that are valuable as food for foliage-gleaning birds.

These bird species have adapted to divide the feeding zones and more efficiently use the mature crowns (MacArthur 1958).

Young Spruce Stands

A dense, uniform canopy of > 90 percent red spruce dominated the habitat structure of the young spruce stands. Tree heights averaged 4.5 m in one stand (Stewart and Aldrich 1949) that had a dense understory of mountain laurel (*Kalmia latifolia*), and 9 m in the other stand (Sigel et al. 1968) that was quite open underneath.

These stands supported an average of 249 pairs/40 ha of breeding birds though the young stands averaged only 17 bird species compared with an average of 23 in the mature stands. The dominant bird species were the magnolia warbler and the dark-eyed junco; both species were also common in mature spruce stands (Table 2), but their densities were twice as high in the young stands as in the mature. While the magnolia warbler is a characteristic species of the upland conifer forest, it is most populous in dense, young developing conifer stands. Dark-eyed juncos nest and forage on the ground as well as in coniferous shrubs and saplings. Both species benefit from the protective cover common in these stands.

Although sparse in mature stands, the Swainson's thrush, winter wren (*Troglodytes troglodytes*), and American robin (*Turdus migratorius*) were common in young spruce stands. The two thrushes were probably attracted to the dense saplings and pole-size softwoods. The winter wren's response to habitat features is similar to that of the dark-eyed junco.

Virtually absent from the young spruce stands were high canopy, foliage-gleaning bird species such as the golden-crowned kinglet and blackburnian and black-throated green warblers.

Mixed Growth Stands

Two of the stands (Martin 1960, Niemi 1972) contained intolerant hardwoods from 12 to 18 m tall, overtopping fir. One stand (Martin 1960) had tolerant hardwoods from 18 to 24 m tall, overtopping fir. Heights of fir ranged from 9 to 12 m. The understory in all stands consisted of a dense growth of shrubs and tree seedlings and saplings.

Red-eyed vireos (*V. olivaceous*) and ovenbirds (*Seiurus aurocapillus*) were the dominant species. Birds usually associated with hardwoods and common in these mixed growth stands were black-and-white (*Mniotilta varia*), Nashville (*V. ruficapillus*), and Canada (*Wilsonia canadensis*) warblers. Yellow-bellied sapsuckers (*Sphyrapicus varius*) were more common in this forest type than in any other. Other common species attracted to the softwoods were the magnolia and blackburnian warblers. Other species that frequent high canopy conifers were sparse or absent.

These stands supported an average of 231 pairs/40 ha, slightly less than were supported by mature spruce stands. Numbers of species were about the same as in mature spruce stands (Table 2).

SILVICULTURE AND BIRD HABITAT

Spruce and fir are tolerant and can be successfully managed with even-age or uneven-age silviculture. Seed-tree systems are not suitable because shallow rooting makes these tree species susceptible to windthrow.

Silvicultural practices modify forest stands by changing plant species composition and the vertical and horizontal structure of vegetation in the stand. Plant composition and structure are the base elements of bird habitat. Many studies have shown that bird populations respond to changes in their habitat (Hagar 1960, Haapanen 1965, Titterington et al. 1979).

We can scale stand modification from "light" (uneven-age silviculture) to "heavy" (clearcutting, followed by site preparation and planting). Between these limits lie many different silvicultural practices. Effects on bird populations differ along this approximate continuum according to the degree of habitat modification (Table 3).

Also, after any disturbance--including that caused by cutting--the patterns and timing of secondary plant succession vary with the geographic location, availability of seed, microclimate, site, and the degree of disturbance.

The successional patterns of bird species in upland coniferous forests are closely related to the plant succession that follows habitat disturbances (Titterington et al. 1979). Each seral stage is characterized by a group of associated bird species.

The following discussion is based primarily on data collected in commercially clearcut spruce-fir forests of northern Maine (Titterington et al. 1979), and on our findings in Maine upland spruce-fir stands. The response by habitat-related groups of bird species to different habitat features should be similar throughout the upland spruce-fir type. Species

Table 3.--The response of birds to habitat modification, by bird habitat group, response time, and silvicultural treatment (A = abundant in species and density; C = common; R = regular; O = occasional)

Response time (years)	Treatment							
	Uneven-age	Large diam-limit	Thinning sawlogs	Thinning poles	Shelter-wood cut	Commercial clearcut & small diam. limit	Silvi-cultural clearcut	Cut, site preparation, & plant
				UPPER CANOPY GROUP				
0 to 5±	A	R	R	R	C	R-O	O	O
5 to 30±	A	R	C	C	O	R-O	O	O
30 to 100±	A	C	--	A-C	C-R	R-O	C	C
				LOWER CANOPY GROUP				
0 to 5±	A	R	R	C	C	R-O	O	O
5 to 30±	A	R	C	C	O	R-O	R	R
30 to 100±	A	C	--	A-C	C-R	R-O	C	C
				SHRUB-SAPLING GROUP				
0 to 5±	R	O	O	R	O	R-O	R-O	O
5 to 30±	R	O	R-O	R-O	C	A-C	A-C	C-R
30 to 100±	R	O	--	O	R	R-O	O	O
				BRAMBLE-HERBACEOUS GROUP				
0 to 5±	O	O	O	O	O	A-C	A	R-O
5 to 30±	O	O	R-O	R-O	C	R-O	R-O	R-O
50 to 100±	O	O	--	O	R	O	O	O
				SLASH-OPEN GROUND GROUP				
0 to 5±	R	R	R-O	O	A-C	A-C	A	O
5 to 30±	R	R	R	R	R	O	O	O
30 to 100±	R	R	--	R	R	R	R	R
				CAVITY NESTING GROUP				
0 to 5±	O	R	R-O	R-O	O	R	R-O	O
5 to 30±	O	R	R-O	R-O	O	R	O	O
30 to 100±	O	R	--	R	O	R	O	O

of birds within the habitat groups may differ because of restricted geographic ranges or different proportions of conifers and hardwoods.

Uneven-Age Silviculture

A well-planned system of single tree or small group selection maintains an uneven-aged stand and, among harvest methods, comes closest to retaining a continuous cover of trees of many ages and heights. Vertical development is at a maximum (Frank and Bjorkbom 1973), which provides more canopy layers than any other silvicultural system. Horizontal diversity is maintained through a mosaic of different sites--resulting largely from glaciation--which form brushy bogs and swamps, blowdown openings, localized natural tree mortality, and localized type anomalies.

At short intervals, mature trees are removed as scattered individuals or small groups to provide a sustained yield of products, even from relatively small ownerships. Competing hardwoods and noncrop softwoods are thinned and weeded at the same time. The time between cuttings on a given area may range from 10 to 25 years, depending on the site and on economic considerations (Frank and Bjorkbom 1973). By frequent harvest cuts, trees that might otherwise die are cut, thus well-managed stands will not have as many standing dead trees.

Bird populations remain more stable with uneven-age than with even-age silviculture. Managed uneven-aged stands at any given time have a greater variety of habitat strata than unmanaged mature spruce stands. Numbers of bird species and densities of individuals would likely equal or exceed the levels found in the mature stands, although there would be fewer mature trees so the upper canopy would not support as many birds. The numbers of golden-crowned kinglets and blackburnian warblers would be less. However, the well-distributed canopies of the low and midstory trees should support more low canopy species

such as the magnolia and yellow-rumped warbler, Swainson's thrush, and the solitary vireo, with an overall increase in numbers. Ground-feeding species such as the dark-eyed junco and white-throated sparrow will be found in small openings. Cavity nesters may be adversely affected.

Even-Age Silviculture

Harvest Cuttings

Clearcutting.--Silvicultural clearcutting is the felling of all stems greater than 2.5 to 5.0 cm in diameter at breast height (dbh). This type of cutting should be done only if advance reproduction or a seed source is available or if the area is to be replanted immediately. It is often advantageous to cut in small patches or narrow strips to facilitate natural seeding. Where environmental conditions are not too severe, the openings should be wider than one tree height and no wider than 25 to 30 m for balsam fir and 55 to 60 m for red and white spruce. Where there is danger of seedling dessication or wind damage, the openings should be no larger than half the height of the trees in the stand. Uncut areas should be at least 10 m wide (Frank and Bjorkbom 1973).

In the upland spruce-fir forest ecosystem, plant succession has five seral stages that follow severe disturbances such as clearcutting (Titterington et al. 1979), and each is characterized by one or more habitat feature: (1) open ground-slash--abundant open ground and dense slash; lasts from 0 to 2 years after disturbances; (2) bramble-herbaceous--dense low layer of brambles and herbaceous plants with scattered small regenerating tree species; lasts 3 to 10 years after disturbances; (3) shrub-sapling--dominated by hardwood and softwood regeneration taller than 2 m; lasts 4 to 20 years after a disturbance; (4) immature second growth--pole-size hardwoods and/or softwoods 10 to 20 cm dbh; lasts from 20 to 50 years after disturbances; (5) mature second growth--dominated by softwood > 20 cm dbh; lasts from 40 to 80 years after disturbances.

Avifaunal succession is directly related to these seral stages. Bird species that nest and forage predominantly on the ground, such as the white-throated sparrow, dark-eyed junco, and winter wren, are closely associated with the first seral stage. The slash commonly left after tree harvesting provides important protective cover for these bird species.

Bird species adapted to nest and forage in dense vegetation close to the ground are closely associated with the second seral stage. The white-throated sparrow, common yellowthroat (*Geothlypis trichas*), chestnut-sided warbler, and mourning warbler (*Oporornis philadelphia*) all reach their highest densities in this habitat. The edges, with a dense growth of brambles, will also be used by these species.

Bird species, such as the white-throated sparrow, magnolia warbler, red-eyed vireo, American redstart (*Setophaga ruticilla*), and Canada warbler are abundant nesters and foragers in the dominant shrub-sapling stratum of the third seral stage. The white-throated sparrow and black-and-white warbler both nest on or near the ground, but spend a large part of their foraging time in saplings.

The substantial lower and midcanopies characteristic in the fourth seral stage provide abundant foraging sites for such species as the solitary vireo, Swainson's thrush, rose-breasted grosbeak (*Pheucticus ludovicianus*), black-throated blue warbler, Tennessee warbler, and the ovenbird. These last three species nest on or near the ground.

The dominant bird species of the fifth seral stage, such as the golden-crowned kinglet, yellow-rumped, black-throated green, bay-breasted, Cape May, and blackburnian warblers, satisfy their foraging and nesting requirements in the upper canopy.

Clearcutting for natural regeneration affects bird populations in proportion to the minimum size of stems cut and the size of areas cut. Upper and lower canopy habitats are eliminated with silvicultural clearcutting, but the understory is retained and a slash habitat may be created. Depending on site quality, in 2 to 4 years, the regenerating trees, herbs, and raspberries increase the understory density and provide habitat for the common yellowthroat, white-throated sparrow, and associated species. When stems 8 to 16 cm dbh are left uncut, some shrub-sapling and lower canopy birds such as the magnolia warbler and its associates will continue to find favorable habitat as will some cavity nesting species. However, this will lessen the understory growth with a resulting decrease in the number of understory birds. Site quality and subsequent thinning will determine the rate at which lower and upper canopies develop and provide habitat for canopy species.

Unlike large cleared areas, small clearcuts--from 2 to 8 ha (5 to 20 acres)--result in different aged stands and a greater variety of bird species found in close proximity at any one time. Long rotations, which result in increased crown development and stand size variety, enhance habitat for more bird species than short rotations regardless of the type of harvest system used in even-age silviculture.

Shelterwood.--Clearcutting small areas can be considered a shelterwood cut if the clearings are less than one-half the height of the trees in the stand. In shelterwood systems, a first harvest is made to establish reproduction and one or more later harvests remove the remaining stand when the regeneration no longer needs protection from wind and excessive insolation (Frank and Bjorkbom 1973).

Shelterwood methods cause the least drastic stand modification of the even-age silvicultural regeneration systems. When the overstory is removed in two or more operations at intervals of 5 to 25 years, the effects on birds are similar to group selection, especially if more than two cutting stages are used. When the last cut removes the remaining overstory, advanced reproduction is well established. Upper and lower canopy birds lose their habitat but shrub and sapling birds such as the magnolia warbler, and bramble-herbaceous birds such as the common yellowthroat, find improved habitat. Species such as the dark-eyed junco will be found in a dominant stratum of slash left after heavy cutting. The slash and shrub-sapling strata diminish with time as tree crowns increase in height and volume, which provides favorable conditions for low canopy species. Eventually the dominant trees again provide habitat favorable for both lower and upper canopy species. Cavity nesters would find little habitat after the final removal cut.

Planting and Seeding

Clearcutting followed by site preparation, planting, and control of competing vegetation causes the greatest disruption of upland spruce-fir stands.

Planting or seeding may be advantageous where natural regeneration is lacking or will take several years to develop, or where the better sites warrant planting superior stock. Competing vegetation and debris may be removed by mechanical means, chemical treatment, or controlled burning before planting or seeding. Generally these treated areas are substantially exposed.

The use of the area by birds would be inversely related to intensity of the practices employed. Heavy slash left in clearcut areas is used by dark-eyed juncos and winter wrens for foraging and nesting. Woodpeckers also forage in slash (Conner and Crawford 1974). When slash is eliminated, the area has little to attract these bird species.

If small seedlings are planted and competing vegetation is controlled, it may be 5 or more years before the area is suitable for species attracted to the shrub-sapling stratum. Depending on the amount of revegetation, some use of the area would probably be made by species such as the Savanna sparrow (*Passerculus sandwichensis*) that nest in open fields. Because plant succession is slower on poor sites, the length of time before shrub-sapling bird groups reoccupy the site may be longer than on better sites. For bird rehabitation, a favorable alternative would be closely spaced plantings of superior growing stock on better sites, with minimum vegetation control, and with slash left in place. The period of time that areas are unsuitable for birds would then be minimized.

Intermediate Cuttings

Even-age silvicultural systems require cultural treatments between harvest cuts to help the stand develop properly.

"Cleanings" done in sapling stands release and increase the growth of potential crop trees by removing nearby competing stems. Cleanings generally remove hardwood from spruce and fir on sites with deep, well-drained soils about 8 years after harvest. Cleanings may be done by cutting or by chemical treatment.

"Thinning" removes trees that compete with crop trees or those that may die before regeneration cuts are due, and speeds up the growth of the residual trees. It is conducted in pole-size and sawlog-size stands (Frank 1973). These cuts may remove 10 to 50 percent of the basal area, depending on the site.

After intensive thinning of hardwood and softwood species in pole-size spruce-fir stands, there is a decrease in use by upper canopy birds; removing softwood trees particularly affects nesting conditions. However, such thinning favors habitat use by lower canopy species.

Intensive thinning in sawlog-size stands releases hardwood understory and herbaceous ground cover, and increases use by shrub-sapling and lower canopy birds; upper canopy species continue to be represented. Continued growth of the hardwood understory creates favorable conditions for ovenbirds; black-throated green, black-throated blue, and Canada warblers; Swwinson's thrush; and rose-breasted grosbeaks. Cavity nesters are adversely affected by thinning such stands unless trees are killed and allowed to remain standing.

Intermediate cuttings decrease the number of hardwood trees in sapling spruce-fir stands during cleaning operations, which results in less use of the area by the black-and-white and Canada warblers, the red-eyed vireo, the American redstart, and associated species. If the weeding is intensive enough to cause a

dense herbaceous growth, this benefits the common yellowthroat and associated species, and it might favor the dark-eyed junco and associated species if the hardwood slash is left.

Forest stands located on good sites respond to thinning more rapidly than stands on poor sites. Consequently, the alteration of habitat on good sites effects changes in bird species representation more quickly and for a shorter time.

Unregulated Methods

Commercial clearcutting and diameter-limit cutting usually remove the largest and best trees from a stand, which results in high grading. The size and quality of stems harvested are usually determined by marketing conditions. These cutting methods are not designed to provide regeneration, but may do so; neither do they generally provide for any cultural treatments. Intensity of harvest may vary from light removal of large trees from old-growth stands to removal of all spruce and fir except culls and saplings.

Large diameter limit harvests do not maintain a proper distribution of tree size classes through thinning. Vertical canopy development would not be as great as in managed uneven-aged stands. Distribution of trees in the lower canopy would be left to chance and the number and density of bird species would be correspondingly less than in managed uneven-aged stands. Habitat for cavity nesters would be favorable because cull trees are left standing.

Small diameter limit cuts and commercial clearcutting open the stand to varying degrees depending on the number of saleable trees. This cutting does not remove stems in the lower size classes, and shrub-sapling and low canopy strata usually are not reduced. Many birds frequenting these habitats remain, or possibly increase, due to increased vegetative growth. If understory vegetation is poorly developed, stands are of less value to birds. Noncommercial or cull overstory trees are left which provide a variable amount of habitat for upper canopy species. Habitat for cavity nesters can be favorable.

SUMMARY

Five seral stages with corresponding bird species succession follow severe disturbance in upland spruce-fir forests:

(1) Open ground-slash--white-throated sparrow, dark-eyed junco, and winter wren.

(2) Bramble-herbaceous--white-throated sparrow, common yellowthroat, chestnut-sided warbler and associates.

(3) Shrub-sapling--white-throated sparrow, magnolia warbler, red-eyed vireo and associates.

(4) Immature second growth--solitary vireo, Swainson's thrush, black-throated blue warbler and associates.

(5) Mature second growth--golden-crowned kinglet, blackburnian warbler, yellow-rumped warbler and associates.

In forest stands, the composition and density of bird communities is affected by the admixture of hardwoods with softwoods, vertical and horizontal stand structure, and degree of spruce budworm infestation in the stands. Based on number of bird species present and population density, we separated forest stands as follows:

Stand	Pairs/40 ha	No. species
Balsam fir	128	20
Mature spruce	264	23
Mixed growth	231	24
Spruce-fir w/budworm	334	34
Spruce-fir no budworm	190	26
Young spruce	249	17

Silvicultural practices modify stands by changing plant composition and vertical and horizontal stand structure. To meet their nesting and foraging requirements, bird populations respond by utilizing the habitat to which they are best adapted.

ACKNOWLEDGMENTS

For advice and technical review, we thank Richard DeGraaf, Norman Famous, Craig Ferris, and Robert Frank.

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