

# Selected studies of forestry and bird communities in Nova Scotia and New Brunswick

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## Abstract

Forestry practices can cause intense disturbances, which result in dramatic changes in the habitats available to support all elements of biodiversity, including birds. Many species of birds require mature and older forests as habitat for breeding, migratory movements, or wintering; some also use habitats occurring during earlier stages of forest succession, including those created through such forestry activities as clearcutting. We summarise results of several research projects which have examined the effects of various harvesting systems, plantation establishment, and silvicultural herbicide spraying in Nova Scotia and New Brunswick.

## Résumé

Les pratiques forestières peuvent causer de grandes perturbations qui résultent en des changements dramatiques dans la disponibilité des habitats nécessaires pour supporter tous les éléments de la biodiversité, incluant les oiseaux. Plusieurs espèces d'oiseaux ont besoin de forêts matures et anciennes comme habitat de nidification, d'hivernage et de déplacements migratoires; certaines espèces utilisent les habitats reliés aux stades de succession de la forêt, incluant les habitats créés à l'aide de pratiques forestières telles que la coupe à blanc. Nous résumons plusieurs projets de recherche qui ont examiné les effets de divers systèmes d'exploitation forestière, d'établissement de plantations et d'application d'herbicides en Nouvelle-Écosse et au Nouveau-Brunswick.

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## Introduction

Intense disturbances of forests are associated with clearcutting and other forestry practices. These result in dramatic changes in the habitats available to support all elements of biodiversity. Some species, guilds, and communities benefit from habitat changes caused by forestry, but others suffer severe harm (Freedman 1989, 1995; Hunter 1990; DeGraaf et al. 1992; Freedman et al. 1994, 1996).

In particular, many species of birds require mature and older forests as habitat for breeding, migrating, or wintering. Many others, however, use habitats occurring during earlier stages of forest succession,

including those created through such forestry activities as clearcutting. In general, disturbances associated with forest harvesting and site management have indirect effects on bird species, guilds and communities, acting through changes in the physical structure and plant species composition of the available habitats. In addition, spraying of forestry pesticides can have direct effects on birds, occurring because of poisoning caused by exposure to toxic chemicals (particularly insecticides).

We describe here the results of studies on effects of forestry practices on birds in Nova Scotia and New Brunswick. The research summarized here examined

the effects of various harvesting systems, plantation establishment, and silvicultural herbicide spraying. The component studies were conducted between 1980 and 1996.

## Methods

All studies involved comparisons of stands that had been modified by forestry, with reference (that is, non-affected) stands in the immediate vicinity (often adjacent to an affected stand). This research design assumes that the habitat of the reference stands was similar in quality to that occurring in the modified stands prior to harvesting or herbicide application.

The research involved use of the spot-map technique to census bird populations. Wherever possible, plot sizes were 10 hectares or more in area. In some cases, however, they were smaller than this, being constrained by the stand-level scale of the operational forestry being practised. However, in each of the studies summarized here, the reference and treatment plots were of a similar size. The perimeter of each plot was marked at 50m intervals, as were 1 or 2 internal transects along the longer axis of the plot. These points were the listening stations where observations of song and other avian behaviour were made. Each census plot was surveyed 10 times (8 morning and 2 evening censuses), beginning in the first week of June and extending as late as mid-July. The locations of singing males were marked on maps of the sites, with particular attention paid to simultaneous registrations of more than one male of the same species. Territories were assigned on the basis of clusters of observations, which were interpreted to represent the activities of individual male birds.

Detailed investigations were also made of habitat structure. The abundance of plant species and foliage cover were measured in three strata: ground vegetation, shrubs, and trees, including snags and coarse woody debris. These habitat data are not reported here, but are available in the original publications that describe the research.

Common and scientific names of all bird species mentioned are given in Appendix 1.

## Component Studies

The following studies are summarized here:

### 1. Harvesting hardwood forest

Fieldwork was conducted during 1980 in central Nova Scotia, in an area of mature hardwood forest dominated by red and sugar maple (*Acer rubrum* and *A. saccharum*) and white and yellow birch (*Betula*

*papyrifera* and *B. alleghaniensis*) (Freedman et al. 1981). Comparisons were made of avian communities in three 3-year-old clearcuts, two 4-year-old strip-cuts (one had 20-m wide strips and the census plot comprised 45% harvested and 55% forest habitat; the other plot had 30m wide strips and was 38% cut and 62% forested), a shelterwood cut (45% residual basal area of non-harvested trees), and three reference stands of non-harvested, mature forest. The reference forest was about 75 years old, and had originated from a natural wildfire. All of the harvested stands were regenerating naturally.

### 2. Avian succession after clearcutting hardwood forest

Fieldwork was conducted during 1980 and 1981 in a region of mature maple-birch forest in central Nova Scotia (Morgan and Freedman 1986). Successional patterns were inferred using data from a chronosequence of 23 stands. There were 13 stands of various ages after clearcutting (up to 20 years), plus 10 reference stands aged 30 to 75 years after a wildfire. All harvested stands were regenerating naturally.

### 3. Intensively-managed conifer plantations

Fieldwork was conducted during 1992 and 1993 in southeastern New Brunswick, in and near Fundy National Park (G. Johnson and B. Freedman, unpub.) The study area is dominated by mature, mixed-species forest dominated by red spruce (*Picea rubens*), balsam fir (*Abies balsamea*), red maple, and white birch. This natural forest has been, and is being, extensively clearcut and converted into intensively-managed plantations of black spruce (*Picea mariana*), which were planted as seedlings. The initial stages of plantation development (up to age 21 years) were examined using a chronosequence of 11 stands of about 10 ha, and these were compared with 5 reference stands of unharvested, natural forest.

### 4. Effects of silvicultural herbicide spraying

Fieldwork was conducted from 1986 to 1990 in central Nova Scotia (MacKinnon and Freedman 1993). The pre-spray avifauna of five census plots in 3-year-old spruce plantations was surveyed initially in 1986. Four of the plots were then operationally treated with glyphosate herbicide in August, 1986 at 2.3 kg/ha, while one plot was left unsprayed as a reference comparison. Post-spray changes in the avifauna were monitored during the first, second, and fourth years after herbicide treatment.

## Results and Discussion

### 1. Harvesting hardwood forest

This study found no substantial differences in the total

abundance, species richness, or species diversity of breeding birds among stands of mature maple-birch forest, or young clearcuts, strip-cuts, or a shelterwood cut of that forest (Table 1). However, the bird species using the mature forest and the recently disturbed habitats were almost completely different. Species prominent in mature stands included Least Flycatcher, Hermit Thrush, Red-eyed Vireo, Black-throated Green Warbler, Ovenbird, and American Redstart. In contrast, species prominent in the young clearcuts included Chestnut-sided Warbler, Mourning Warbler, Common Yellowthroat, Dark-eyed Junco, White-throated Sparrow, and Song Sparrow.

Strip-cuts included both mature-forest and clearcut habitats, and the bird species segregated among these habitat elements within the strip-cut area. The shelterwood cut had about one-third the tree

density, basal area, and canopy cover of the mature forest, with abundant shrub and ground vegetation. These intermediate habitat conditions supported some bird species of mature forest and some of clearcuts, particularly Least Flycatcher, Red-eyed Vireo, Chestnut-sided Warbler, Mourning Warbler, Common Yellowthroat, American Redstart, and White-throated Sparrow.

## 2. Avian succession after clearcutting hardwood forest

The chronosequence of 23 stands of clearcuts and natural hardwood forest showed that once the clearcuts had regenerated for at least three years, there was no substantial difference in bird community variables (such as total density, species richness, and species diversity) among stands of different age, in spite of

**Table 1.** Density of breeding birds of 3 stands of mature hardwood forest, 3 clearcuts, a shelterwood cut, and two strip-cuts in Nova Scotia. The mature forest was dominated by maple and birch; all harvests were 3-5 years old. The shelterwood and strip-cuts had a habitat structure intermediate to the forest and clearcuts. Data are in pairs/10 ha., averaged within each of the habitat types. Uncommon species are not included. Modified from Freedman et al. (1981).

Species	Mature forest	Clearcut	Shelterwood	Strip-cut
Common Snipe	0.0	0.8	0.0	0.0
Ruby-throated Hummingbird	0.0	2.3	0.0	0.0
Least Flycatcher	13.7	0.0	14.0	8.0
Hermit Thrush	4.3	0.0	0.0	0.8
Veery	2.0	0.8	0.0	0.8
Solitary Vireo	3.0	0.0	0.0	0.8
Red-eyed Vireo	5.3	0.0	8.0	5.0
Black-and-white Warbler	3.5	0.0	0.0	4.3
Northern Parula	2.8	0.0	0.0	2.5
Black-throated Green	3.7	0.0	0.0	0.8
Chestnut-sided Warbler	0.0	11.0	11.0	6.0
Ovenbird	15.7	0.0	0.0	8.0
Mourning Warbler	0.0	3.0	8.0	1.0
Common Yellowthroat	0.0	15.2	8.0	2.5
American Redstart	6.5	0.0	3.0	9.0
Rose-breasted Grosbeak	0.8	0.0	0.0	0.0
Dark-eyed Junco	1.7	5.0	0.0	2.3
White-throated Sparrow	0.7	12.7	3.0	0.0
Song Sparrow	0.0	5.3	0.0	0.0
<b>Total density</b>	<b>66.3</b>	<b>58.8</b>	<b>55.0</b>	<b>52.5</b>
<b>Species richness</b>	<b>12</b>	<b>8</b>	<b>7</b>	<b>13</b>
<b>Species diversity (H')</b>	<b>2.1</b>	<b>1.8</b>	<b>1.8</b>	<b>2.2</b>

great differences in habitat (Figure 1). Only the 1- and 2-year-old clearcuts had smaller bird populations than uncut stands; the range of total avian density of clearcuts 3 to 10 years old fell within the range of variation of density for mature stands. As in the previous study (1, above), a distinct suite of bird species occurred relatively early in the post-clearcutting succession, and these were later replaced by another group as clearcuts matured into hardwood forest.

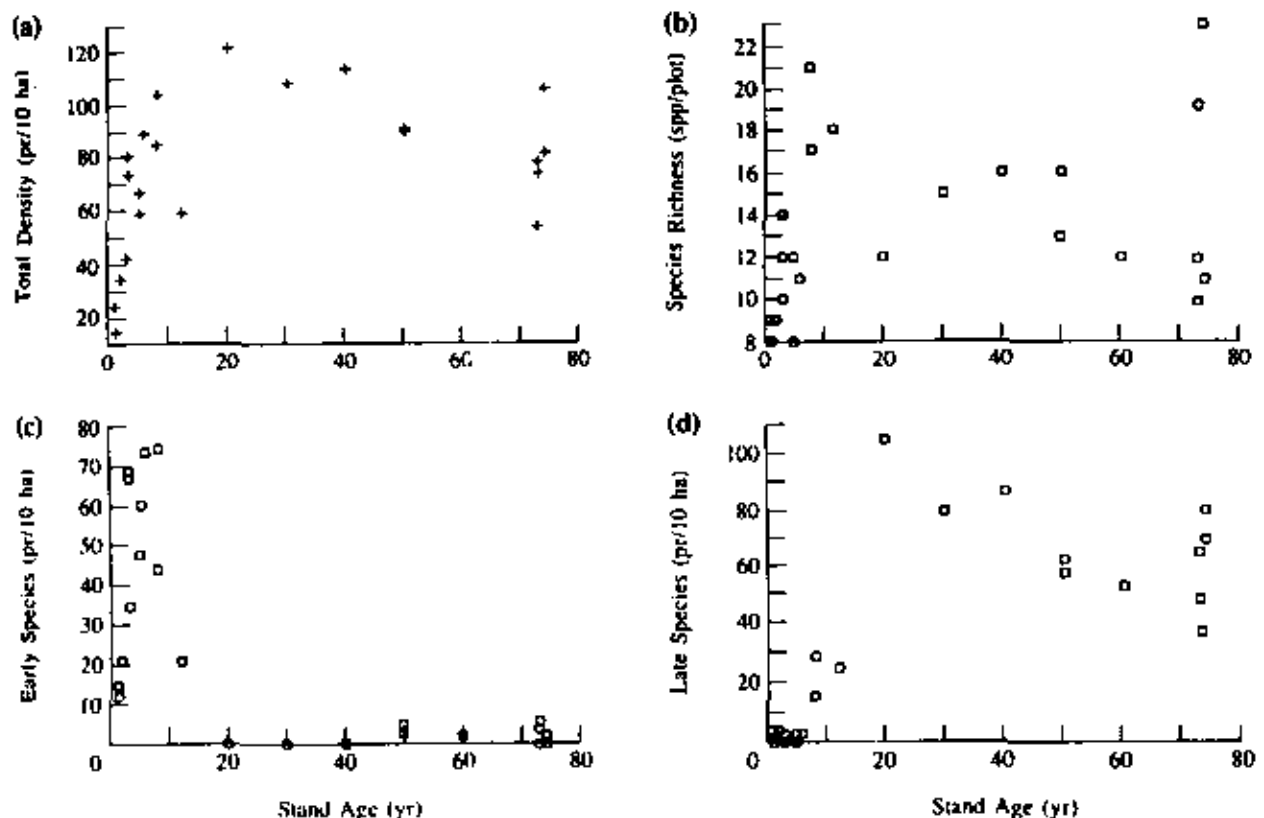
The transition between these avian communities occurred largely in stands 12-20 years old (Morgan and Freedman 1986). During this period hardwood stump sprouts and saplings had thinned to relatively few stems with a canopy at about 8-12 m. At the same time the shrub and ground-vegetation strata were declining in prominence because of shading exerted by

the overhead canopy of trees. This habitat maturation allowed the progressive invasion of the stand by bird species characteristic of mature forest. The distinctness of the "early" and "late" avian communities was demonstrated by a cluster analysis of the data matrix of bird species abundance versus stand age. This multivariate procedure separated the avian communities of stands 1-12 years old from those of stands 20-74 years old. Clusters of stands within these two age groups were much weaker, indicating that their avian communities were rather similar (Morgan and Freedman 1986).

### 3. Intensively-managed conifer plantations

Avian density reached pre-cutting levels within 5 years of plantation establishment, and peaked at about 15

**Figure 1.** Avian community parameters in a chronosequence of 23 stands in an area of hardwood forest in Nova Scotia. Stands older than 20 years were part of a post-fire landscape mosaic, while younger stands originated with clearcutting. (a) total density of breeding species; (b) number of breeding species; (c) species prominent in younger stands (i.e., Alder Flycatcher, Chestnut-sided Warbler, Common Yellowthroat, Dark-eyed Junco, White-throated Sparrow, Song Sparrow); (d) species prominent in mature stands (i.e., Least Flycatcher, Hermit Thrush, Veery, Red-eyed Vireo, Black-throated Green Warbler, American Redstart, Ovenbird). Modified from Morgan and Freedman (1986), and Freedman (1995).



years (Table 2). The avian community of younger plantations was dominated by ground-nesting species, particularly Common Yellowthroat, Lincoln's Sparrow, Song Sparrow, and White-throated Sparrow. The density of these species increased quickly, and then generally decreased to lower levels in the oldest plantations and reference stands of mature mixed-species forest. The density of canopy-nesting species (Yellow-bellied Flycatcher, Ruby-crowned Kinglet, Magnolia Warbler, and Yellow-rumped Warbler) was very low until tree-sized plants became established, after a plantation age of about 13 years. Plantations aged 13 to 15 years maintained relatively high populations of both ground- and canopy-nesting birds.

Notably absent or sparse in conifer plantations were cavity-nesting birds such as woodpeckers, chickadees, and nuthatches. (The only exceptions were single pairs of Eastern Bluebird and Northern Flicker in a 5-year-old plantation, nesting in the only two snags in the census plot.) Owing to the intensive management system used to develop the plantations examined, the quantities of coarse woody debris, snags, and cavity trees were very small compared with natural reference forests (Table 3). Consequently, few or no opportunities were provided for species of birds that require these elements as essential components of their habitat (Freedman et al. 1996).

A total of 16 species that bred in natural forest

Table 2. Breeding birds in 16 stands of natural, conifer-dominated forest and spruce plantations near Fundy National Park, New Brunswick. Only relatively abundant birds are listed. Bird numbers in pairs/10 ha; stand age in years; X = <0.5 territories per plot; V = visitor (included in species richness) (G. Johnson and B. Freedman, unpublished data).

Species	Plantation (age in yr.)									Forest		
	3	4	5	6	7	8	13	15	21	M	M	M
Common Snipe	1.3		1.0	1.0	1.0		1.0					
Common Nighthawk	V	1.0	V		V	1.0						
Yellow-bellied Flycatcher							18.0	6.9	13.0	4.7	1.0	4.5
Alder Flycatcher				5.3		6.0	V	13.4				
Black-capped Chickadee								X	X	X	3.0	2.0
Red-breasted Nuthatch							X	V	V	3.4	3.0	2.0
Brown Creeper										1.7		1.5
Winter Wren										2.1		0.5
Golden-crowned Kinglet								2.0	8.0	4.2	2.0	6.0
Ruby-crowned Kinglet				V			4.5	5.0	7.5	1.3		0.5
Swainson's Thrush								0.5	3.0	4.7	2.5	3.0
Hermit Thrush	V					0.5	0.5	2.0	2.0	2.5	2.0	
American Robin	V	X	X	V	0.5		0.5	X	2.5	0.4		
Solitary Vireo							V	V		0.4	3.0	1.0
Nashville Warbler	V						V	3.5	3.0	0.8		
Northern Parula								V		1.3		0.5
Magnolia Warbler				1.9		0.5	9.0	13.4	8.5	10.6		7.0
Black-throated Blue Warbler										3.8	3.5	1.5
Yellow-rumped Warbler							5.5	5.4	7.0	2.5	4.5	7.5
Black-throated Green Warbler							V	V	4.5	2.5	5.0	7.5
Blackburnian Warbler									6.5	5.1	9.5	5.0
Palm Warbler				V	4.0	5.5	9.0	9.5	1.0			
Bay-breasted Warbler									4.5	2.1	0.5	6.0
American Redstart				V			V	1.5		V		1.0
Ovenbird										1.7	8.0	5.0
Common Yellowthroat	0.9	2.0	3.0	15.0	4.0	11.0	10.0	15.3				
Song Sparrow	4.8	8.0	18.5	4.4	21.0	9.5						
Lincoln's Sparrow	4.3	15.5	16.0	10.2	21.5	11.0	6.0	5.9				
White-throated Sparrow	X	3.5	3.0	12.6	4.0	9.5	18.0	8.4	9.5	1.7		X
Northern Junco	3.5	X	X	1.0		0.5	2.0	2.5	4.0	2.5	2.0	4.0
Purple Finch							V	V		0.8	2.0	X
Total bird density	16.5	30.6	43.4	54.3	56.2	55.4	84.6	104.6	86.0	68.3	54.0	70.3
Species richness	17	11	12	18	12	15	27	36	24	41	25	32
Species diversity (H')	1.8	1.3	1.4	1.9	1.4	2.0	2.2	2.7	2.6	3.1	2.6	2.9

**Table 3.** Snags (dead trees), coarse woody debris (CWD), and living trees in stands of natural forest and conifer plantations in vicinity of Fundy National Park, New Brunswick. Data are for snags, CWD and trees with diameter  $\geq 5$  cm. Snags and live trees in basal area ( $m^2/ha$ ); CWD volume in  $m^3/ha$ . (T. Fleming and B. Freedman, unpubl. data).

	Snags	CWD	Live tree
<b>Mature, natural forest</b>			
Hardwood	3.5	18.7	29.3
Mixedwood	3.6	19.9	29.1
Mixedwood	5.4	13.0	28.0
Mixedwood	4.1	32.7	33.1
Conifer	11.4	41.6	25.4
Conifer	19.5	45.4	30.5
Conifer	12.7	56.5	27.7
<b>Plantation forest</b>			
21-yr.-old spruce	0.03	0.6	15.1
15-yr.-old spruce	0.0	8.9	10.8
15-yr.-old pine	0.1	0.0	28.8
13-yr.-old spruce	0.2	14.1	5.6
8-yr.-old spruce	0.2	28.0	5.1
7-yr.-old spruce	0.0	21.4	0.0
7-yr.-old spruce	0.0	23.9	0.5
6-yr.-old larch	0.0	32.1	0.3
5-yr.-old spruce	0.0	23.7	0.0
5-yr.-old spruce	1.8	55.3	0.0
4-yr.-old spruce	0.0	52.2	0.0
3-yr.-old spruce	0.0	48.1	0.0
3-yr.-old spruce	0.0	81.2	0.0

plots in the present study were not found in the plantations, including three species of cavity nesters and five species that prefer or require forest with a significant component of angiosperm trees. However, clearcutting and subsequent plantation establishment did provide temporary site opportunities for many open-canopy species of birds, and later on, species of conifer-dominated forest. If plantations were adjacent to natural forest, they were also used by some forest species for foraging. In general, our results are similar to those of Parker et al. (1994) for plantations elsewhere in New Brunswick. The effects on avifauna that we observed are, however, less severe than have been reported in studies of intensively managed

conifer plantations in Europe and the southeastern United States (Moss 1978; Repenning and Labisky 1985).

#### 4. Effects of silvicultural herbicide spraying

Only small changes in the abundance and species richness of breeding birds occurred on clearcuts treated with glyphosate herbicide (Table 4). Avian abundance decreased between the pre-spray and first post-spray years. However, this change occurred on both the sprayed and reference plots, which suggests it may have been caused by factors unrelated to the herbicide treatment (such as bad weather during the breeding, migrating, or wintering seasons). In the second year after spraying, the abundance of birds on the sprayed plots remained similar to that during the first post-spray year, while that of the unsprayed plot increased to about the pre-spray value. In the fourth post-spray year the treatments differed little in avian density.

The most common species on the clearcuts were White-throated Sparrow and Common Yellowthroat. These had a somewhat lower abundance on the spray plots up to the second post-spray year, and then recovered by the fourth post-spray year. On the reference plot, Song Sparrow and Lincoln's Sparrow declined in abundance during the course of the study, but on the sprayed plots these species were most abundant in the second and fourth years after spraying. As succession proceeded the reference plot became colonized by some new species in low densities, including Black-and-white Warbler, Red-eyed Vireo, Ruby-throated Hummingbird, and Palm Warbler. These species did not invade the sprayed plots, because the herbicide treatment had caused the habitat to revert to a younger successional stage, which was less favourable to these birds.

The effects of a herbicide treatment on animals using regenerating clearcuts as habitat can be caused by two types of influences: (1) direct toxicity of the herbicide, and (2) changes in the character of the habitat. Compared with many insecticides, herbicides used in forestry (particularly 2,4,5-T, 2,4-D, glyphosate, hexazinone, and triclopyr) are not very toxic to animals (Freedman 1995). At exposures encountered during typical forestry uses, the direct toxicological risks of these chemicals appear to be small and unimportant. This is particularly true of glyphosate, the most commonly used herbicide in forestry in Canada.

Glyphosate use does, however, cause large

**Table 4.** Range of abundance of breeding birds among five clearcut plots treated with glyphosate herbicide, and one reference plot. Only abundant species are listed; data are pairs/ha, determined by spot-map census, prior to spraying and in the first, second and fourth subsequent years. Data for sprayed treatment are ranges among five separate plots. Modified from MacKinnon and Freedman (1993).

Species	Reference plot (years)				Spray plots (years)			
	Pre-spray	1	2	4	Pre-spray	1	2	3
Common Yellowthroat	12	11	12	16	13-19	10-16	7-12	7-18
White-throated Sparrow	14	7	9	16	18-24	10-14	8-11	13-18
Dark-eyed Junco	3	4	6	10	3-7	5-8	4-8	5-8
Song Sparrow	4	2	1	1	3-5	1-4	5-7	6-14
American Goldfinch	6	4	2	2	3-8	2-3	0-3	0-3
<b>Total bird density</b>	<b>54</b>	<b>40</b>	<b>53</b>	<b>84</b>	<b>53-81</b>	<b>38-53</b>	<b>38-52</b>	<b>60-92</b>
<b>Species richness</b>	<b>12</b>	<b>15</b>	<b>15</b>	<b>12</b>	<b>10-14</b>	<b>10-15</b>	<b>12-15</b>	<b>12-13</b>

changes in habitat, by affecting the productivity and biomass of plants, and consequently changing the availability of berries and other plant foods. These changes indirectly result in smaller populations of insects and spiders, which are important foods for most birds, particularly during the breeding season (Freedman 1995; Woodcock et al. 1997). In our study, however, these potential, indirect effects of herbicide spraying resulted in only small changes in the populations of breeding birds.

## Summary

Our studies in Nova Scotia and New Brunswick found that forestry-related disturbances result in large changes in the habitat available for breeding birds. Many bird species occupying natural, mature forests found these habitat changes to be unsuitable. However, areas disturbed by forestry provided breeding habitat for indigenous, early-successional species. In terms of abundance, species richness, and species diversity, the overall changes in avian communities were not large, at least once clearcuts or plantations reached several years of age.

In general, intensively-managed plantations had greater effects on bird habitat than naturally regenerating sites. One of the most important differences in this regard involves critical habitat for bird species dependent on snags, cavity trees, and coarse woody debris.

Many of the effects of forestry on avian communities can be avoided if forest managers ensure that adequate areas of closed-canopy, mixed-wood and

angiosperm-dominated forest always remain available on the landscape. In addition, areas converted to plantations should be allowed to retain or regenerate a substantial component of deciduous trees, and actions should be undertaken to ensure the availability of snags, cavity trees, and coarse woody debris as critical habitat for dependent species.

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### Appendix 1. Common and scientific names of bird species mentioned in this paper.

Common name	Scientific name	Common name	Scientific name
Common Snipe	<i>Capella gallinago</i>	Northern Parula	<i>Parula americana</i>
Common Nighthawk	<i>Chordeiles minor</i>	Magnolia Warbler	<i>Dendroica magnolia</i>
Northern Flicker	<i>Colaptes auratus</i>	Black-throated Blue W.	<i>D. caerulescens</i>
Ruby-throated Hummingbird	<i>Archilochus colubris</i>	Yellow-rumped Warbler	<i>D. coronata</i>
Least Flycatcher	<i>Empidonax minimus</i>	Black-throated Green W.	<i>D. virens</i>
Alder Flycatcher	<i>E. alnorum</i>	Chestnut-sided Warbler	<i>D. pensylvanica</i>
Yellow-bellied Flycatcher	<i>E. flaviventris</i>	Bay-breasted Warbler	<i>D. palmarum</i>
Black-capped Chickadee	<i>Poecile atricapillus</i>	Palm Warbler	<i>D. palmarum</i>
Red-breasted Nuthatch	<i>Sitta canadensis</i>	Blackburnian Warbler	<i>D. fusca</i>
Brown Creeper	<i>Certhia familiaris</i>	American Redstart	<i>Setophaga ruticilla</i>
Winter Wren	<i>Troglodytes troglodytes</i>	Ovenbird	<i>Seturus auracapillus</i>
Ruby-crowned Kinglet	<i>Regulus calendula</i>	Nashville Warbler	<i>Vermivora ruficapilla</i>
Golden-crowned Kinglet	<i>R. satrapa</i>	Mourning Warbler	<i>Oporornis philadelphia</i>
Eastern Bluebird	<i>Sialia sialis</i>	Common Yellowthroat	<i>Geothlypis trichas</i>
American Robin	<i>Turdus migratorius</i>	Rose-breasted Grosbeak	<i>Pheucticus ludovicianus</i>
Swainson's Thrush	<i>Catharus ustulatus</i>	Purple Finch	<i>Carpodacus purpureus</i>
Hermit Thrush	<i>C. guttatus</i>	Dark-eyed Junco	<i>Junco hyemalis</i>
Veery	<i>C. fuscescens</i>	White-throated Sparrow	<i>Zonotrichia albicollis</i>
Solitary Vireo	<i>Vireo solitarius</i>	Song Sparrow	<i>Melospiza melodia</i>
Red-eyed Vireo	<i>V. olivaceus</i>	Lincoln's Sparrow	<i>M. lincolni</i>
Black-and-white Warbler	<i>Mniotilta varia</i>		