Bird Species Richness and Composition in White Pine (*Pinus strobus*) Stands in Algonquin Provincial Park, Ontario in response to the First Cut of the Uniform Shelterwood Silvicultural System*

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Abstract

The response of birds and vegetation to the first cut of the white pine (*Pinus strobus*) uniform shelterwood sylvicultural system was examined in Algonquin Provincial Park, Ontario. Bird abundances and vegetation cover in stands which were logged during the period of 1970 - 1994 were compared to mature stands with no recorded logging history. Old-cut stands contained most (89%) of the 63 species recorded during the study. Of these, only seven showed significant differences in abundance among the treatments. The most important habitat variable for these seven bird species appeared to be the amount of understory vegetation and cover in the forest canopy. Open forest species such as white-throated sparrows (*Zonotrichia albicollis*), chestnut-sided warblers (*Dendroica pensylvanica*), and mourning warblers (*Oporornis philadelphia*) were more abundant in stands logged between 1970 and 1978, and between 1986 and 1994, where the canopy cover was the least dense. Bird species richness was greatest in unlogged stands and in stands logged between 1978 and 1986, the two treatments with the greatest structural diversity. Plant species richness was greatest in stands logged between 1970 and 1986 suggesting birds were selecting habitat based upon forest structure rather than plant species composition. We recommend longer rotation periods, preservation of super-canopy trees and some additional reserves for old-cut stands. We also recommend that private landowners adopt, when possible, this silvicultural technique.

Introduction

White pine *(Pinus strobus)* is an economically and ecologically important species in Canada's mixed and southern boreal forests, especially in the Great Lakes-St. Lawrence Forest Region (Lowe, 1994; Naylor et al., 1994). The management of these forests has recently been the focus of debate, as it is estimated that 80% of Central Ontario's forest-inhabiting wildlife use forests that contain red (*Pinus rugosa*) or white pine (Naylor et al., 1994).

Recent declines in neotropical migrant bird populations have been a cause for concern in both their breeding and wintering grounds, and habitat change is implicated as one of many possible explanations for the decline (Robbins et al., 1989, Thompson et al*.,* 1995). Changes in the breeding and wintering habitats of

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birds are due to a variety of factors, including logging and silvicultural practices. Logging causes habitat change that may significantly affect avian populations at both the landscape and stand level (Franzreb and Ohmart, 1978; Thompson et al., 1995). A great deal of information exists on how birds respond to clear-cut logging (Conner et al., 1979; Freedman et al., 1981; Steffen, 1985; Wetmore et al., 1985; Norton and Hannon, 1997), but there is very little information on the effects of other silvicultural systems on bird habitats (Franzreb and Ohmart, 1978; Freedman et al., 1981; Thompson et al., 1995).

The uniform shelterwood silvicultural system differs from other even-aged silvicultural systems by gradually removing the original forest rather than removing all or most trees in an initial cut. In theory, a series of four cuts – preparation, seeding, first removal, and final removal – done in twenty year intervals, gradually remove the original stand while regeneration becomes established under the existing stand's canopy (Corbett, 1994; Algonquin Forestry Authority (AFA), 1995; Thompson et al., 1995). The entire process is repeated after the passing of a further 40 years when the regeneration is 80 years old (AFA 1995).

When uniform shelterwood logging was first employed in the early 1970s, it was at a trial stage. Tree removal techniques and marking requirements were unrefined, and the percentage of pine removed was greater than at present, resulting in poor pine regeneration and profuse deciduous growth (Pick, pers. comm.). The different harvesting techniques used in the early 1970s, and the unsuccessful pine regeneration that followed, have disallowed the use of stands logged at that time as reliable indicators. It cannot be determine with any precision, what a typical first cut in the uniform shelterwood silvicultural system will be like in 20 years, although results were included in the analysis for comparative purposes. Therefore, only the first stage of the cutting has been completed to date using the method as it has been refined. Our purpose was to determine the effects of this first cutting of the uniform shelterwood sylvicultural system on the abundance and richness of breeding birds, and on the vegetation structure of logged and unlogged stands in the pine forests of Algonquin Provincial Park, Ontario.

Study Sites and Methods

The study was conducted on the east side of Algonquin Provincial Park, Ontario, Canada (44°10'N, 77°23'W). This area is dominated by white pine forests with trees between 80 and 100 years in age and 25-30 m in height (Martin, 1959). The white pine forests in the study area are relatively continuous, separated only by logging roads and water bodies.

Forest stands with different logging histories were divided into four treatments: those logged between 1986 and 1994; 1978 and 1986; or 1970 and 1978. These are hereafter referred to as "90s", "80s" and "70s" treatments, respectively. The fourth treatment was composed entirely of stands without a written logging history – hereafter referred to as "old-cut" – although the entire region was known to have been logged between 80 and 100 years ago (Naylor et al., 1994). Stands logged prior to 1970 were not included in this study because logging techniques other than the shelterwood system were used during those years. Stands were chosen using Forest Resource Inventory (FRI) maps in addition to

Ontario Ministry of Natural Resources (OMNR) and AFA logging history records. For a stand to be chosen it had to be accessible by road, have a minimum stand composition of 50% white pine, contain trees that were a minimum age of 70 years, fall into one of the prescribed treatments, and be a minimum of 15 hectares in size.

Once stands were located, survey points for breeding birds were set up within each stand – hereafter referred to as 'plot'. Points were flagged at least 200 m from roads, water bodies or stand boundaries to minimize possible effects of edge habitat on bird and vegetation communities. A total of 39 bird census plots were used in the spring of 1995 (14 old-cut, 8 70s, 10 80s) and 55 bird census plots were used in 1996 (15 old-cut, 12 70s, 11 80s, 12 90s).

Vegetation Survey

A total of 38 plots, ten in each of the 70s and 90s treatments, and nine in each of the old-cut and 80s treatments, were surveyed once in 1996, after the completion of the bird surveys in July. To determine the floristic characteristics present at each site, a square 400 m^2 quadrat was set up within each of the plots. It was centred at the point count station used during the bird surveys, with its sides parallel to the four compass directions. Diameter at breast height (dbh) measurements were taken for all trees and snags greater than 10 cm dbh in the quadrat. Percent cover estimates were also taken for six vertical forest layers: from 0 to 0.33 m in height; from 0.33 to 2 m; from 2 to 5 m; from 5 to 10 m; subcanopy; and canopy.

To measure percent cover of the first two layers – ground and less than 2 m – a smaller 1 m^2 quadrat was randomly placed within the 400 m^2 study quadrat and aided by a placed grid system. For each survey, this was repeated ten times, each placement exclusive of all others. The percent cover of each species was estimated within each of the 1m^2 quadrats. For each species present, the percent cover was estimated within each of these four quadrats for the remaining forest layers. As percent cover was estimated for each species and many species overlapped in space, total cover could be greater than 100%. All plants were identified to species. Plant species were grouped into broad categories – mosses, equisetums, ferns, herbaceous plants, shrubs and coniferous and deciduous trees – and were analyzed using one-way ANOVAs for each of the vegetation categories in each of the forest layers.

Surveys of Forest Breeding Birds

In both years, breeding birds were monitored using a ten minute, 50 m - unlimited distance point count as used by the Canadian Wildlife Service's Forest Bird Monitoring Program (Cadman, 1995). Counts were done twice for each point and were performed in the morning between dawn and 9:30 am, and were done during weather other than rain, hail or appreciable wind, all of which would affect the ability to hear birdsong (Bibby et al., 1992). Both heard and sighted birds were counted. To reduce problems associated with observer bias, only two experienced observers performed surveys and were given approximately equal numbers of stands in each treatment to census, the same observer visiting the same set of plots for both of the two visits. The order in which the stands were surveyed was determined using a random number table. Totals of birds counted beyond the 50 m circle (unlimited distance) were combined with totals from within the 50 m circle as an index of relative abundance for a stand (Bibby et al., 1992).

Results

1. The general features of vegetation changes through each stage of the first cut of the uniform shelterwood silvicultural system are outlined in Figure 1.
2. Few significant differences were found among treatments in the percent cover of different vegetative layers. Old-cut and 80s treatments had significantly greater amounts of coniferous and total cover in the canopy than the 70s and 90s treatments; the amount of deciduous cover in the 2-5 m layer was significantly greater in the 70s treatment than the other three treatments; and percent cover of ferns in the less than 2 m forest layer was significantly greater in the 90s treatment than the remaining treatments.
3. We found few weak (non-significant) trends in the other forest layers. The sub-canopy layer appeared to have greater cover in old-cut and 80s treatments; the amount of total cover in the 5-10 m forest layer appeared greatest in the 70s treatment (P =0.090). At ground level, the 80s treatment had the greatest amount of total cover, but this only approached significance (P =0.069).

Figure 1: Diagram of change in forest structure from the old-cut to the resulting forest (80 years) under a uniform shelterwood silvicultural technique

4. Plant species richness was highest in the 90s plots. The basal area of snags did not vary statistically between the treatments; however, the basal area of white pines and of all species combined was significantly greater in the old-cut treatment.
5. A total of 63 species of birds were recorded in the two years of study. Of this total the greatest number observed in any one treatment during one year was 52 in 1995 in the old-cut treatment . The old-cut treatment also had the largest total number of species observed – 89% of all species – and the greatest number of species unique to it. Four species – ruby-throated hummingbird, American crow, white-breasted nuthatch and wood thrush were found only in the old-cut treatment. The 80s treatment had the second highest richness, comprising 84% of all species observed.
6. Average avifauna richness of the plots among treatments – i.e., number of species/plot – was marginally higher in the 70s plots than in the old-cut and 80s plots (*P*=0.054) in 1995, but the data from 1996 did not support the first year's results (*P*=0.325). When the data from the two years were combined – excluding the 90s treatment because of no replicates in 1995 – the 80s plots had the highest average species richness (*P*= 0.035).
7. Old-cut and 80s treatments were most similar in bird communities, with similarities in other treatments in decreasing order: 70s and 80s; 70s and 90s; 80s and 90s; old-cut and 90s; with old-cut and 70s treatments being the least similar (Kingsley, 1998).
8. Of the 28 species that were analyzed for differences in relative abundances among treatments – i.e., those species that occurred in at least five plots of each treatments – seven showed a significant difference among treatments for one or both years as follows:
   - Black-capped chickadee: Old-cut treatments had significantly greater relative abundance than the other treatments (Kruskal-Wallis ANOVA, F=16.9745, *P*=0.0007).
   - Veery: The abundance of veery differed significantly between the treatments (ANOVA, F=2.913, *P* =0.039). Veery were significantly more abundant in 70s plots compared to old-cut (LSD Multiple Comparison test, *P*=0.029) and 90s plots (LSD Multiple Comparison test, *P* =0.009), but were only slightly more abundant than 80s cuts.
   - Chestnut-sided warbler: This species occurred with significantly greater abundance in the 90s treatments than the other treatments, with 70s and 80s treatments having smaller but good numbers. Low numbers were found in old-cut stands (Kruskal-Wallis ANOVA, F=22.3296, *P*=0.001).
   - Ovenbird: The pattern of relative abundance was complicated by yearly variation. In 1995, no significant difference between the treatments was found (ANOVA, F=1.956, *P*=0.1595). However marginally significant differences among treatments were found in 1996 (ANOVA, F=2.805, P=0.051). The 80s treatment had significantly lower numbers than the old-cut treatment (LSD Multiple Comparison test, *P*=0.013) and the 70s treatment (LSD Multiple Comparison test, *P*=0.038). There also existed a significant difference between the two years with respect to overall abundance. In 1996 we found more ovenbirds, although the 80s treatment showed the least difference between years.
   - Mourning warbler: This species was found in low numbers in all treatments except in the 90s treatment where mourning warblers

occurred in relatively high abundance (Kruskal-Wallis ANOVA, F=13.0637, *P*=0.005).

- Canada warbler: Canada warblers were few in number except in the 70s treatment, where they are found in significantly greater abundance than in the other treatments (Kruskal-Wallis ANOVA, F=16.744, *P* =0.001.
- White-throated sparrow*:* White-throated sparrows were significantly more abundant in the 90s treatment than in the old-cut stands (ANOVA, F=4.685, *P*=0.004, LSD Multiple Comparison test, *P*=0.000); 80s plots (LSD Multiple Comparison test, *P*=0.038); and the 70s plots (LSD Multiple Comparison test, *P*=0.044).

Discussion

Old-cut stands, that had no record of cutting, are presumably the closest in vegetation structure and bird communities to original old-growth white pine forests in central Ontario. These stands had bird communities very similar, sharing 94.3% of species, to those cut in the 1980s with the uniform shelterwood silvicultural system. Therefore, it appears that the ten to twenty years that have passed since active logging has allowed many of the layers of the white pine forest to expand to the degree present in old-cut stands. These two treatments differed in important ways from the more recently cut 90s plots and the 70s plots where this particular silviculture system was in its first experimental stage. In particular, the canopy layer of the 80s and old-cut treatments was significantly greater in cover than the other two treatments, and were not significantly different from each other, hence providing similar amounts of canopy habitat for canopy inhabiting birds.

The 80s and old-cut treatments also contained similarly low amounts of deciduous cover in the 2-5 m layer and fern cover – primarily bracken fern *(Pteridium aquilinum)* an open area species – in the less than 2 m forest layer. For both layers the amount of cover was lower than that found in the 90s and 70s treatments respectively. Old-cut and 80s treatments had the greatest total bird richness per treatment and the greatest structural diversity as indicated by the intermediate percent cover results in the different forest layers, and the presence of a well-formed canopy and sub-canopy. Lower structural diversity was inferred in treatments with little cover in one or more layers. For example, both the 70s and 90s plots had low amounts of canopy cover. The 90s treatment also had a low amount of shrub cover in the 2-5 m layer. Birds in our study, as in others (MacArthur et al., 1962; Karr and Roth, 1971; James and Warmer, 1981; Niemi and Hanowski, 1984; Steffen, 1985; Thompson et al., 1995) appear to be selecting habitat based on forest structure, rather than plant species composition. The old-cut and 90s treatments were most similar in plant species composition – sharing 82.4% of species while the 70s and 80s treatment shared 64.5% and 68.2% species respectively – but least similar in bird species composition.

The vegetation characteristics resulting from this mixture of treatments appeared to have positive and negative impacts on a relatively small number (seven) of the species observed in all treatment groups. We discuss these according to their primary habitat preferences and how they were affected by the changes in the forest structure.

Snag users: Snags – standing dead wood – are an important habitat component for many species (Quinby, 1988; Naylor et al., 1994; Naylor et al., 1996). A great deal of research and interest in snags has shown that increased numbers of snags in an area – including clearcuts – increases the numbers and diversity of birds significantly (Dickson et al., 1983). However, the number of snags is often negatively affected by forestry practices (Quinby, 1988). A total of nine snag dependent species – yellow-bellied sapsucker, downy woodpecker, hairy woodpecker, black-backed woodpecker, northern flicker, pileated woodpecker, black-capped chickadee, brown creeper, and red-breasted nuthatches – were observed in the study, five of which had sufficient numbers for analysis. Of this number only the black-capped chickadee showed a significant difference between the treatments and none of the others was exclusive to the old-cut treatments.

Chickadees are cavity nesters and prefer to excavate their nests in standing tree stumps with an average diameter of 10 to 18 cm at breast height (Peck and James, 1987). Chickadees also nest more frequently in deciduous tree snags, with birch trees as the most commonly used species (Smith, 1993; Peck and James, 1987). The greatest relative abundance of chickadees was found in old-cut stands in both years and this is possibly a result of the abundance of suitable snags in this treatment. Suitable nesting snags may be a limiting factor for black-capped chickadees (Smith, 1993). If these snags are not available or are in low numbers, chickadees will be in lower abundance. Although not significant, the basal area of snags is greatest in the old-cut and 80s treatments, followed by the 70s treatment and the 90s treatment. The greater number of snags, and possibly greater number of deciduous tree snags – though this was not measured – in old-cut stands may explain the abundance pattern of black-capped chickadees in the treatments.

Unlike chickadees, woodpeckers require larger snags for nesting. For example, yellow-bellied sapsuckers nest in trees with an average diameter of 25.5 to 33 cm at breast height (Peck and James, 1987). Because the number of snags greater than 10 cm dbh did not differ significantly between the treatments, woodpecker nesting trees were not negatively affected, possibly explaining why none of the woodpecker species showed a significant difference in abundance between the treatments. Larger snags required by woodpeckers were maintained by the provisions made by the AFA, but smaller ones (less than 10 cm dbh), appear to have been reduced by logging as indicated by chickadee abundance.

Canopy dependant species: For many species that directly use the canopy layer for foraging and/or nesting, or for species that require canopy cover as a general habitat feature, it appears that the first cut did not remove enough of the canopy to negatively affect their numbers. However, their requirements for canopy cover suggest that future cuts will probably have a negative effect upon these species. Golden-crowned kinglet, Swainson's thrush, solitary vireo, black-throated green warbler, black-throated blue warbler, Blackburnian warbler, pine warbler, and black and white warbler were found in all treatments and showed no significant differences in their abundance. However, many showed lower numbers in the low canopy 70s and 80s treatments than the other two treatments.

Open shrubby habitats: Three species that prefer open habitats and a dense shrub layer were significantly more abundant in the 90s and 70s treatments than the other treatments. These species were chestnut-sided warbler, mourning warbler and white-throated sparrow. This finding is shared with and confirmed by many other workers studying the impact of forestry on bird populations (Cadman et al., 1988; Falls and Kopachena, 1994). Although the amount of shrub cover was expected to be linked to the abundance of these species, no significant difference was found in the percent cover at the shrub layer despite the observed differences in chestnut-sided warbler, mourning warbler, Canada warbler and white-throated sparrow abundance. Although there was a significant difference in the amount of canopy cover between the treatments, with the 90s and 70s treatments having the lowest amount of canopy cover and thus a more open forest. The combination of an open forest and a sufficient shrub layer make the habitat in these two treatments more suitable than the 80s and old-cut treatments. Freedman et al. (1981) obtained a similar result to this study, showing in the case of the white-throated sparrow its preference for open areas. White-throated sparrows were found to be most abundant in clearcuts, followed by thinned stands and uncut areas (Freedman et al., 1981).

Dense understory habitat: Canada warblers and veeries prefer habitats with dense understory vegetation (Noon et al., 1979; Collins et al., 1982; Peck and James, 1987; Moskoff, 1995) and were both significantly more abundant in the 70s treatment than the other treatments. Ground cover did not differ significantly between the treatments and therefore the amount of ground cover does not appear to be the factor responsible for the large numbers of veeries and Canada warblers found in the 70s treatment. The amount of canopy cover is also not likely to be a factor because these species were not abundant in the 90s cut. The explanation for higher abundance indices for these species is probably due to the significantly denser understory found in the 70s stands. This treatment had a significantly higher total percent cover in the 2 to 5 m layer and higher cover in the 5 to 10 m forest layer that approached significance. In addition to the greater amount of total vegetation cover in the 70s treatment, there was also a much larger amount of deciduous cover at the 2 to 5 m level. The combination of a high percentage of deciduous and total cover created ideal habitat for Canada warblers and veeries in the 70s treatment.

Ground dwelling species: The winter wren was the only wren species observed, and was very abundant in all treatments. Winter wrens typically breed in dense, moist coniferous forests with a dense ground cover of shrubs, woody debris, herbaceous plants and mosses (Cadman et al., 1988). The first cut did not appear to negatively affect winter wrens. Woody debris remained abundant in all treatments although in different stages of decay (Kingsley, 1998). Ground cover vegetation and shrub species in the less than 2 m layer did not differ significantly. These are probably the most important habitat features for Winter wrens as they both nest and forage near the ground and would be influenced mostly by change in this microhabitat (Richard, 1988).

Ovenbirds breed in mature mixed forests with dense understory vegetation above the shrub layer (Cadman et al., 1988; Van Horn and Donovan, 1994). The nest is built on the ground in the shape of a dutch oven, with leaf litter and surrounding vegetation concealing it (Cadman et al., 1988; Van Horn and Donovan, 1994). Their need for leaf litter leads to their preference for nesting areas with relatively low amounts of ground vegetation (Burke and Nol, 1998). The high amount of ground cover observed in 80s treatments, although only approaching significance (*P*=0.069), may explain the significantly lower abundance of ovenbirds in this treatment in the second year of the study.

Generalists: These species did not show a significant difference in abundance between the treatments because of their general habitat requirements. These species included: ruffed grouse, blue jay, hermit thrush, American robin, red-eyed vireo, Nashville warbler, magnolia warbler, yellow-rumped warbler, rose-breasted grosbeak, and purple finch (Cadman et al., 1988).

Other: Many species were found in low numbers. In general, more of these were found in the old-cut stands. Although white pine forest was probably not the preferred habitat for some of these species, for example, olive-sided flycatcher, eastern wood pewee, least flycatcher, great crested flycatcher, gray jay, white-breasted nuthatch, yellow warbler, American redstart, common yellowthroat, northern waterthrush, scarlet tanager, chipping sparrow and song sparrow, or the study area was at the edge of their range, for example, wood thrush. It is illuminating that the landscape with old-cut forests provides more habitat for a greater variety of species overall, than the cut landscapes. However, this result is not seen when the average richness of the plots is examined.

Summary and Recommendations

The results of this study show that there are differences between the treatments in both vegetation characteristics and in the breeding bird species richness and abundances. The significant differences observed appear to be the result of a strong preference for one or more vegetation characteristics found in certain treatments. This study only examined the first cutting stage and future cuts will have different impacts on the vegetation structure and bird species composition.

Due to their dependence on mature coniferous trees and a well formed canopy, species such as red-breasted nuthatch, golden-crowned kinglet, Swainson's thrush, solitary vireo, black-throated green warbler, black-throated blue warbler, Blackburnian warbler, pine warbler and red crossbill are considered vulnerable to population declines as a result of logging practices with short rotation periods (Reed, 1992). Some of these species had lower numbers in the 70s and 90s treatments – low canopy treatments – in the first cut, suggesting that future cuts will have an even greater impact on these species. Future cuts in the uniform shelterwood system will make the forest unsuitable as canopy trees will be removed and probably will not regenerate to such a degree as to maintain the integrity of the forest before the second cycle of cutting begins.

The rotation age of a stand strongly influences the vegetation structure of the forest. Thompson et al. (1995) believed that commercial rotations could result in a decline of species belonging to several guilds, such as cavity-nesters and foliage-gleaners, resulting in a lower diversity of breeding birds within a stand. Rotation times are often much shorter than the natural disturbance regime. This causes the future stand to lose structural characteristics associated with old stands that are needed for bird diversity (Thompson et al., 1995). This was also found in our old-cut stands where overall bird species richness was higher than for any of the more recently logged stands, when viewed collectively − rather than as individual stands − within the landscape of the eastern half of Algonquin Park.

We recommend an extension of the 80 year rotation period that is planned for these forests to protect against possible future loss of structural diversity. Rotations of 130 to 150 years appear appropriate for the white pine forests of Algonquin Provincial Park as this gives the forest enough time to regain its natural structure (Stiell, 1978). In addition to extending the rotation age, we also suggest that the final cut should not remove all remaining mature canopy trees but instead approximately 10% should remain so that there will always be a canopy component of the forest.

We also recommend that, because old-cut forests support more species in the landscape than the more recent cuts, that additional old-cut stands should be removed permanently from cutting in Algonquin Park to increase the beta diversity of the park overall. Finally, this silvicultural technique should be extolled as it has – based on stand by stand comparison – relatively minor impacts on the avifauna of the park. Private landowners should be strongly encouraged to adopt this method of logging as a means of ensuring the regeneration of pine throughout the privately held remnants of this ecosystem in Ontario.

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