动物学报　52(Supplement): 687–691, 2006
Acta Zoologica Sinica

S39-3　Building a bird-friendly forest: lessons from the boreal forest of Canada

Susan J. HANNON
Dept. of Biological Sciences, University of Alberta, Edmonton, Alberta, T6G 2E9, Canada; sue-hannon@ualberta.ca

Abstract　Many parts of the boreal forest of Canada are being harvested for the first time. Research on the effects of forestry, primarily clearcutting, on birds has focused mainly on (1) documenting impacts of forest fragmentation (edge creation, isolation, patch size effects) and their mitigation (reserve design, provision of corridors), (2) investigating the natural disturbance model as a guide to forest harvesting at several spatial scales, (3) searching for critical thresholds in landscape and cutblock forest cover, (4) assessing the cumulative effects of several land uses, such as forestry, oil and gas extraction, agriculture, roading, and (5) attempting to construct indices of "ecological integrity" at stand and landscape scales that can be used in monitoring for forestry impacts. I review the studies conducted to date in the boreal mixedwood forest of Alberta, and evaluate whether this research has helped forest managers in landscape planning and monitoring. The major research needs for bird conservation in a working forestry landscape are addressed.

Key words　Forest bird communities, Edge effects, Fragmentation, Clearcutting, Corridors, Monitoring

1　Introduction

The boreal forest is the most extensive ecosystem in North America, and until recently, human impacts have been relatively few. Avian species richness is high in this ecosystem compared to that in other systems in North America (Robbins et al., 1986), particularly in the boreal mixedwood. However, the rate of development of forestry has increased in the last 20 years and, in concert with other human disturbances, has led to an increase in forest fragmentation and a decrease in older seral stages (Schmiegelow et al., 1997). Determining the impact of these changes on boreal bird populations is crucial, especially if these areas serve as source populations for other more severely affected ecosystems (Robinson et al., 1995).

The boreal mixedwood forest region is situated south of the northern coniferous forest and north of the aspen parkland in Alberta and Saskatchewan, Canada. This region has been affected increasingly by human disturbance. Clearing for agriculture is prevalent along the southern fringe and in the Peace River area. Transportation routes, pipelines, and seismic lines have bisected many areas. Small-scale harvesting of white spruce (*Picea glauca*) for saw logs is common, and large-scale harvest of aspen (*Populus tremuloides*) for pulp and paper began in 1992. The pure aspen and aspen-dominated mixedwood forests are coming under increasing pressure from logging companies.

The province of Alberta contains over half of the Mixedwood Ecoregion in Canada, and the government has leased over 75% of its mixedwood area to forestry companies under Forestry Management Agreements. Mature (50–100 yr) and old (>100 yr) aspen forests are slated to be cut first. The rotation period will be 40–70 years, so few stands of aspen will reach old-growth stage. Most stands are clearcut in a checkerboard pattern, and average cutblock size is 40 ha (maximum 60 ha). The intervening uncut blocks are harvested when trees on the original cutblocks are about 3 m tall. If the pattern continues, it will result in high fragmentation of the forest, high edge-to-area ratios in the remaining uncut portions, and a lack of large continuous stands of older aspen and mixedwood. Old aspen and mixedwood forests are structurally distinct from younger stands and have higher avian species richness (Schieck et al., 1995). In addition, salvage logging, common after fires, reduces the amount of natural early-seral-stage forest.

Studies aimed at evaluating the effects on forest songbirds of forest fragmentation by clearcutting have been ongoing in the boreal mixedwood forest of north central Alberta since 1993 (Fig. 1). This forest is a mosaic of trembling aspen, white spruce, and jack pine (*Pinus banksiana*) stands in upland sites and of black spruce (*Picea mariana*), balsam poplar (*P. balsamifera*), white birch (*Betula papyrifera*), and tamarack (*Larix laricina*) in lowland sites. Peatlands, other wetlands, and lakes generally occur in areas of low relief. Forest stands had not been harvested previously, and natural disturbances are primarily fire, insect outbreaks, and wind throw.

The purpose of the present paper is to outline the foci of research activities on forestry impacts on birds in this region and to provide an overview of results to date. In addition I will evaluate whether these studies have provided concrete information that will help forest managers to conserve birds. I end with a set of research questions, listed in order of priority, that should be addressed for the long-term conservation of birds in this managed forest system.

2 What research questions have scientists asked?

Avian research in the boreal mixedwood has focused on the following questions:

1. What are the impacts of forest fragmentation on bird communities and populations?
2. Are the effects of logging similar to those of fire?
3. Are there critical thresholds in forest cover below which species loss and/or population decline is accelerated?
4. What are the impacts of cumulative effects of different land uses on bird biodiversity?

2.1 Forest fragmentation

The bulk of research to date has focused on the impacts of forest patch size, edge effects, and the influence of isolation on bird communities and populations. Overall, these impacts have not been large and can be summarized as follows. The larger the patch, the higher the species richness; and patches surrounded by clearcutting do not differ in richness from those embedded in continuous forest (Schmiegelow et al., 1997). Species turnover is higher in the smallest fragments and species composition dominated by edge species (1–10 ha). Abundances of resident species and neotropical migrants are lower in isolated fragments. Some bird species compensate for fragmentation effects by using adjacent habitats (Norton et al., 2000).

Most of the work on edge effects is concerned with reproductive output and density of songbirds at edges compared with those in the forest interior. Nest-predation rates on artificial nests are not higher at edges than in interior forest (Cotterill and Hannon, 1999; Song and Hannon, 1999; Tittler and Hannon, 2000), nor are predation rates higher in forest fragments than in continuous forest (Cotterill and Hannon, 1999). Songbird density is not greater at forest-clearcut edges but rather is related positively to structural heterogeneity of the stand and stand age (Song, 1995). Of 16 common species, none avoided edges, 3 were attracted to them, and 13 were neutral with respect to territory location and edge (Song, 1995). In another study, abundance of forest-dependent bird species declined in linear strips as they narrowed from 200 to 20 m wide (Hannon et al., 2002).

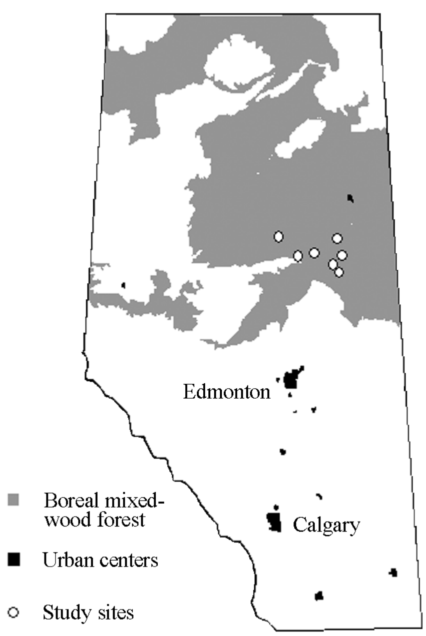

Fig. 1 The province of Alberta, Canada, with boreal mixedwood forest shaded and study sites indicated by circles

Patch isolation does not appear to deter movement to or colonization of patches isolated by clearcutting. Although large gaps in forest cover were avoided by some species (Desrochers and Hannon, 1997; St. Clair et al., 1998) which used corridors when provided (Machtans et al., 1996), gap permeability to bird movement increased as clearcuts regenerated (Robichaud et al., 2002). An analysis of species abundances in isolated, connected, and control reserves up to 5 years after harvesting indicates that provision of corridors does not increase abundance for most species (Hannon and Schmiegelow, 2002), although resident species appear to be more sensitive to isolation than other groups.

Overall, the impacts of fragmentation appear to be low in this system, perhaps because the forest has a high frequency of natural disturbances such as fire. Boreal bird species may therefore be adapted to dealing with gaps. Given the rapid regeneration in clearcuts, moreover, any fragmentation effects are short-lived, and changes in predator communities or invasions by cowbirds do not occur (Schmiegelow et al., 1997; Cotterill and Hannon, 1999). Most of the population-level work has focused on common species, however; rare species could not be analyzed statistically.

2.2 Comparative effects of logging and fire

Increasingly, the forest industry is embracing the concept of “ecosystem management” to ensure that harvesting is conducted in an ecologically sustainable manner. A recent focus has centered on attempts to pattern forest harvesting to resemble that created by natural disturbance, predominantly fire (Hunter, 1993). A critical prerequisite for implementing such a management scheme is a thorough understanding, at stand and landscape scales, of the effects of natural disturbances on wildlife communities and how they compare with the effects of logging.

In the mixedwood, bird community composition in early postdisturbance burned and logged stands differs markedly. In burns, the community is dominated by cavity nesters and species that forage on beetle infestations in the dead trees, whereas clearcuts are dominated by open-country species (Hobson and Schieck, 1999). Between 12 and 25 years after disturbance, the vegetation structure and composition of burns and clearcuts converge, as does bird community composition (Hobson and Schieck, 1999; Schieck and Song, 2002). Some species, such as black-backed woodpeckers (*Picoides arcticus*) and three-toed woodpeckers (*P. tridactylus*), appear to reach their highest densities in recent burns, exploiting wood-boring insect larvae (Cerambycidae, Bupresitidae) and bark-beetle larvae (Scolytidae). Both species are otherwise absent from mature forests but re-appear in older forest at low density (Hoyt and Hannon, 2002). Over the long term, burns may be temporal sources for fire specialists (Hutto, 1995; Hoyt and Hannon, 2002).

The most important current threat to biodiversity and birds associated with recently burned forest is salvage logging. Salvaged trees are in the same diameter classes that woodpeckers use for foraging and nesting (Hoyt, 2000), and densities of three-toed woodpeckers, black-backed woodpeckers, downy woodpeckers (*Picoides pubescens*), and hairy woodpeckers (*P. villosus*) are lower in salvage-logged than unsalvaged burns (Schmiegelow et al., 2001). In addition, secondary cavity nesters such as house wrens (*Troglodytes aedon*), American kestrels (*Falco sparvarius*), and brown creepers (*Certhia americana*) are also more abundant in unsalvaged burns (Schmiegelow et al., 2001).

Colonization of forest tracts that are surrounded by burns or clearcuts may be influenced by such landscape-level loss of forest cover. In a recent study I examined the influence of burns or clearcut logging in the landscape (within 1 km of the sampling location) on the probability of detecting a species in an intact stand of aspen-mixedwood (Hannon, 1999). Some species responded positively to burning in the landscape, some responded positively to logging, some responded negatively to logging, and others responded positively to both burning and logging. The presence of other species was not related to disturbance at the landscape scale.

2.3 Critical thresholds in forest cover

Critical thresholds are levels of a resource below which small changes in the configuration of that resource will produce abrupt shifts in ecological response (With and Crist, 1995; With and King, 1999). Critical thresholds in forest cover leading to species losses or dramatic declines in abundance have been theoretically (With and Crist, 1995; Fahrig, 1997) and empirically (Andren, 1994) predicted to be ~20%–40%. In the boreal mixedwood, we are currently testing for critical thresholds of landscape forest cover on resident owls, passerines, grouse, and woodpeckers by sampling these species at landscape level across a range of forest covers and configurations in different regions. Data collection is ongoing, but preliminary results indicate that, of six owl species sampled, only the barred owl (*Strix varia*) showed a threshold response to amount of forest cover (Grossman and Hannon, unpublished data; Fig. 2).

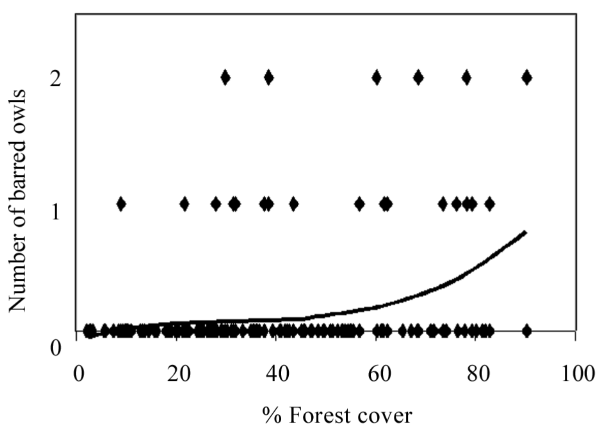

Fig. 2 Number of barred owls detected in 15-km² landscapes that differed in extent of forest cover

2.4 Cumulative effects of different land use

Research has recently been initiated to examine the cumulative effects on bird community composition of forest loss due to logging, oil and gas development, agriculture and linear development such as roads, pipelines and seismic lines. These studies are being conducted at fine scales within a single landscape (S. Hannon, unpublished data) and at large scales across an ecoregion (F. Schmiegelow, unpublished data). Studies on forest cover thresholds and cumulative effects should contribute to identifying species that are particularly sensitive to forest loss and human disturbance. The Biodiversity Group of the Network of Centres of Excellence in Sustainable Forest Management (NCE/SFM) is working to develop a multispecies index of ecological integrity to be used in biodiversity monitoring for the boreal forest.

3 Preliminary conclusions and relevance to management

Most forestry companies in Alberta have embraced the concept of ecologically sustainable forest management and look to researchers to provide recommendations for maintaining biodiversity in managed forests. Foresters want answers to three simple questions: (1) What forest type should be maintained on the landscape (e.g., composition, seral stage)? (2) Where should this forest type be located on the landscape? (3) How much of this forest type should be left? Although these questions sound simple, they are challenging to answer. To date, research conducted in Alberta's boreal mixedwood has provided answers to question 1 but not to questions 2 and 3. We know that intact burned forest and old-growth forest must be present, but we cannot say how much of this forest should be maintained or where it should be located. In a recent review of studies on focal species conducted by NCE/SFM researchers, I found that very few studies provided quantitative recommendations for forestry cutblock or landscape planning (Hannon and McCallum, 2002). The result has been increasing frustration among forest managers with researchers.

Tackling applied ecological research projects is difficult because of the spatial and temporal complexity of ecosystems, the problems of finding the appropriate spatial scale, and the species specificity of many biotic responses to forestry techniques. Obviously, impacts cannot be tested on every species. The common approach of testing null-hypotheses, moreover, may allow us to determine whether a particular treatment has an effect but it does not enable us to tell managers how much edge is too much. Focusing on testing a range of conditions experimentally will provide more insight and allow quantitative prediction of the effects of different levels of perturbation (also O'Connor, 2000).

4 How researchers can help management build a bird-friendly forest

1. Before beginning a study, try to identify the species most likely to be sensitive to changes in forest cover, structure, and composition, such as seral-stage specialists and species with large home ranges.

2. Focus studies on habitats that are most likely to be adversely affected by forestry activities, such as early and late seral stages.

3. Design research to search for thresholds in species response across a range of conditions in order to answer the question "how much?"

4. Consider the influence of the matrix surrounding forest patches on the responses of birds to forestry.

5. Evaluate the impacts of forestry in the context of other land uses in the area, which contribute to cumulative effects.

6. Develop methods for study and evaluation of impacts on rare species.

7. Use this information to help design monitoring programs for forestry companies.

Acknowledgements I thank the many field assistants and technicians who helped with field work, especially C. McCallum, R. Brown, and K. Hannah; C. McCallum prepared the figures. F. K. A. Schmiegelow collaborated in the design of the Calling Lake study. Logging to isolate the reserves in the Calling Lake Fragmentation Study was conducted by Alberta Pacific Forest Industries and Vanderwall Contracting. The work was funded by National Fish and Wildlife Foundation (Partnership in Flight), Wildlife Habitat Canada, Alberta Pacific Forest Industries, Daishowa-Marubeni Industries, Forestry Canada, Alberta Environmental Protection, and the Natural Sciences and Engineering Research Council of Canada.

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