Forest/Wildlife Research in Algonquin Park
The 90s

Abstracts of a Symposium held at the Algonquin Park Visitor Centre, Dec 13-14, 2000

PRFO Occasional Paper Series
Occasional Paper No. 1

A Joint Publication by Algonquin Provincial Park and
Parks Research Forum of Ontario

Parks Research Forum of Ontario

ONTARIO PARKS

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Edited by: Norm Quinn and Greg Mason

Cover Photo: Blackburnian Warbler, (*Dendroica fusca)* by Jim Flynn

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PREFACE

This is the first in what is planned as a series of joint publications for parks and protected areas issued by the Parks Research Forum of Ontario (PRFO) in co-operation with Forum partners. In joining in this cooperative effort PRFO is attempting to support and facilitate the conduct and publication of research relevant to parks and protected areas and the dissemination of such research for wider conservation use.

The specific objectives of PRFO are:

- to promote research to improve understanding, planning, management and decision-making for parks and protected areas;
- to encourage educational and training activities relating to parks and protected areas;
- to facilitate more co-operation in parks and protected areas research
- to establish a meeting place for people involved in parks and protected areas research;
- to exchange information on a regular basis among people involved in parks and protected areas research; and,
- to monitor and report on research on parks and protected areas

In working toward these objectives PRFO has focused to date on the holding of an annual meeting and publication of the proceedings. Two additional activities were added in 2001. The first was the organisation of a monitoring workshop with Ontario Parks in the afternoon of the second day of the 2001 conference, hosted by York University at Black Creek Pioneer Village, May 9-10. About 80 people attended this event which represented a significant effort by Ontario Parks to invite comment, at an early stage, in it's planning for a monitoring system.

The second new initiative was the preparation of this joint report by Algonquin Provincial Park and PRFO on forest/wildlife research in Algonquin which was the focus of a symposium held in the park December 13-14, 2000. The report is a welcome step forward, despite the considerable variation in the depth and style of the abstracts. Although the amount of information that the reader can gain from this publication is limited, it does present an opportunity to follow up with park staff or the authors. The main benefit is that the publication will make Algonquin research more widely known. Such research is of value for its own sake and also in contributing to better planning, management and decision making in the future. We are very grateful for the support of Ontario Parks in this project.

J.G. Nelson

Chair, Parks Research Forum of Ontario

Steering Committee and Members of PRFO

Tom Beechey, Ontario Parks
John Marsh, Frost Centre for Canadian Heritage and Development Studies
John Wadland, Frost Centre for Canadian Heritage and Development Studies
Tom Nudds, Faculty of Science, University of Guelph
Nancy Pollock-Ellwand, School of Landscape Architecture, University of Guelph
Dawn Bazely, York University (in process)

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INTRODUCTION

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The 1990's saw a veritable explosion of research on the subject of forest-wildlife management in Ontario, much of this being spurred by the completion of the Ontario Forest Management Environmental Assessment. Algonquin Park has long been a centre for ecological research; the Park contains three research stations from which hundreds of publications have been produced in the natural sciences. It is not surprising, then, that much of the forest-wildlife work, in the 90s, was conducted in Algonquin Park.

Much of the work reported here was conceived and/or supported financially by the Ontario Ministry of Natural Resources and Ontario Parks. The majority of the studies, however, were initiated independently and became available to park managers more or less fortuitously. Once the extent of the work that was underway became clear, we made attempts to coordinate the various studies under one umbrella. This was done primarily by using funds available from Ontario Parks to connect projects to a major study of hardwood forest-wildlife diversity directed by Dennis Voigt and Ed Addison, which is the subject for the first of the 18 abstracts published here. Despite our efforts to consolidate things, most of the research continued to progress independently and there remained a need to integrate the work. Toward the end of the decade, there was talk of producing a monograph to incorporate all of the work under one cover. When it became clear that that idea was unworkable, it was decided to have a Symposium to bring the researchers together to celebrate and record the extraordinary amount of work that had been done. That symposium was held at the Algonquin Visitor Centre on December 13 and 14, of 2000.

The studies reviewed here range from fascinating work with the history and ecology of downed wood in lakes to an assessment of logging impact on ground beetles and a habitat model for moose. The richest theme is that of avian ecology for which there are eight abstracts. If there is one common thread in the studies it is that selection cutting in tolerant hardwoods does not appear to alter significantly forest structure and composition and diversity of the vertebrate biota. Research in similar ecosystems**,** primarily in the northeastern U.S., supports that general conclusion (Mitchel *et al.*, 1997; Degraff, 1992). It should be noted, however, that much of this work is still to be completed and the reference, or "control" sites used for comparison were not, strictly speaking, “natural”; most having being logged themselves earlier in the 1900s.

The work presented here should, if nothing else, impress the reader with the sheer volume of research that is conducted in Algonquin Park and it should be an important contribution to that rich legacy.

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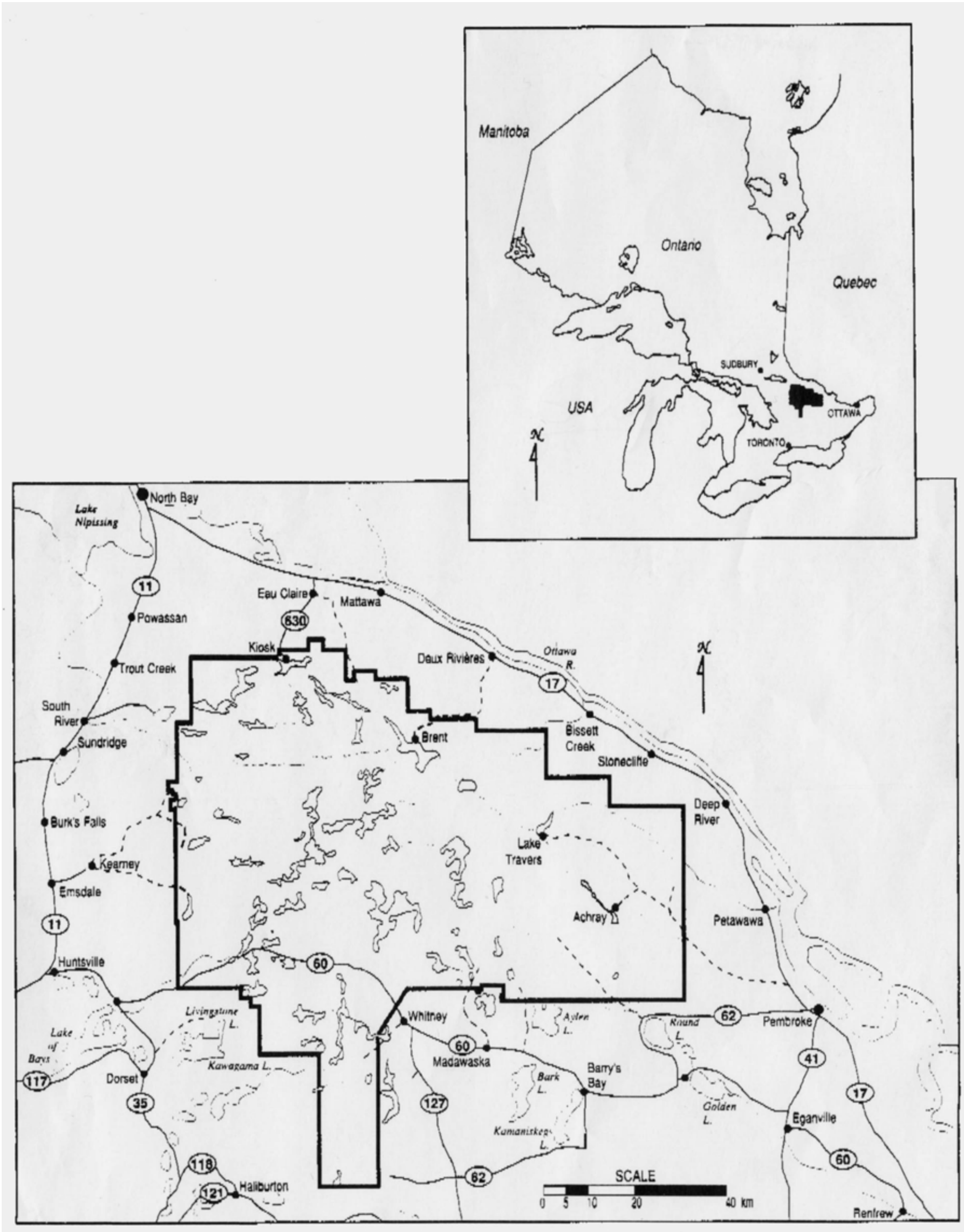
Degraff, R. M. 1992. Effects of Even-Aged Management on Forest Birds at Northern Hardwood Stand Interfaces. Forest Ecology and Management.46: 95-110.

Algonquin Provincial Park: Provincial Context



Source: Algonquin Provincial Management Plan

ABSTRACTS

A Comparison of Forest-Wildlife Habitat in Selection Logged and Un-logged Hardwood Landscapes in Algonquin Park

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We measured the forest-wildlife habitat in tolerant hardwood forest landscapes in Algonquin Park during the late 1990s. The major hypothesis tested was: "*There are no differences in forest structure and composition between landscapes with timber harvesting disturbances and landscapes with natural disturbances but no timber harvesting*." Comparisons were made between a Louisa Lake study area subject to selection logging during the past 30 years and a Canisbay Lake study area closed to logging during the same period.

Elements of habitat structure and composition were measured along randomly located transects, one kilometre long, in each of the study areas. Since many wildlife species range beyond stand-sized patches, this design allowed us to assess the landscape level differences as well as site and stand level effects. Nested plots were located along transects at intervals of 50m. Plots varied from 2 x 2 m to 50 x 25 m in size depending on the element being measured. The following elements were measured: trees; shrubs; snags; fallen wood (coarse woody debris); herbaceous cover; stand vertical structure and layer volume; canopy closure; land cover type; Forest Ecosystem Classification cover type; Ecological Land Classification; disturbance types; frequency; and age. We also recorded all vertebrate wildlife species and wildlife signs found on the 50m x 25m plot. Other measures of wildlife responses and logging road disturbances were part of the study but not reported here. Preliminary analyses of transect level data have shown differences between logged and unlogged landscapes although impacts on wildlife are unknown.

No differences were found in total canopy closure (85% logged vs. 81% unlogged) or conifer canopy closure (5% logged vs. 21% un-logged). Total basal area of trees was greater in unlogged areas primarily due to more super-sized trees (39 vs. 3 m^2/ha). In contrast there were more small trees, notably beech (*Fagus grandifolia)* and yellow birch (*Betula alleghaniensis*), in logged areas although there was no difference in shrub density. We did note a different species composition of shrubs however, with yellow birch, raspberry (*Rubus* spp.*)*, hazel (C*orylus cornuta)* , hemlock (*Tsuga canadensis)*, and red maple (*Acer rubrum)* dominant in logged sites but more balsam fir (*Abies basamea)* in unlogged sites. The volume of vegetation at various layers did not show any differences. Overall snag density was similar but logged areas had more pole-sized snags and more plots with no snags, whereas un-logged areas had more saw and super-sized snags. There were no differences in stump density but as expected there were more logged stumps in logged areas but unlogged plots had more stumps from natural causes. 20 of 140 logged area plots did not show evidence of recent logging, but only 12% of all logging occurrences were within the past 5 years. In both logged and unlogged landscapes, grazing by moose ranked as the most common disturbance followed by fallen trees (wind-thrown). Our field observations suggest moose have changed both species composition and structure of the forest. Anthropogenic disturbances totalled 1169 occurrences in the logged area versus only 163 in unlogged. Total numbers of non-anthropogenic disturbances were similar (1518 vs. 1885 climatic and 1381 vs. 1606 non-climatic). The data collected from this study are available to assist in the future tests of hypotheses of the effects of disturbances on wildlife populations.

A Comparison of Pre-Settlement and Present Diversity Of the Forests of Central Ontario

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Original Crown Survey notes were used to infer the European pre-settlement forest diversity condition in the management units of Algonquin Park, French-Severn, Nipissing and Temagami in Central Ontario, Canada. This diversity condition was then compared to the 1990 diversity of the forests as determined from Forest Resource Inventory (FRI) maps. This study analyzed selected compositional proportions of the forest to identify significant changes that have occurred since 1890.

Ten sub-divided townships were randomly selected from Algonquin Park, French-Severn and Nipissing while all available non-subdivided townships were used in the management unit of Temagami. The 1890 data represented the pre-settlement condition of the forest and acted as the baseline to which the 1990 data were compared. The 1890 data were derived from the original Crown Survey notes which were the forest cruise notes of the day, giving detailed descriptions of the forest cover including species composition, abundance, diameter at breast height and disturbances. The data from 1990 were provided, by the Ontario Ministry of Natural Resources, in the form of FRI maps and spreadsheets. The data were sorted into working group proportions, hardwoods and softwood, shade tolerance groupings and frequency of occurrence.

This study revealed that in terms of changes in working group proportions there have been region-wide significant increases in maple (*Acer* spp), while balsam fir (*Abies balsamea*), hemlock (*Tsuga canadensis*) and, the ‘other conifer’ group, consisting of larch (*Larix larcina*) and cedar (*Thuja occidentalis*), have significantly decreased. This study also revealed that there has been a significant increase in the proportions of hardwoods in the region with a subsequent decrease in the proportion of softwoods. The analysis of shade tolerance groupings showed that there has been a significant increase in the shade tolerant species while no significant changes have occurred with the mid-tolerant species or the shade intolerant species. The regional analysis of frequency of occurrence of each species revealed that a total of ten of the fourteen species have significantly changed.

This study has shown the usefulness of the Crown Survey notes in reconstructing the pre-settlement condition of these forests. These survey notes were easily available and could be simply converted to spreadsheet form. Future forest management plans should attempt to use these data as they will allow for more informed decision-making and will lead to a better understanding of original diversity conditions.

Reference:

Leadbitter, P. 2000. A Comparison of Pre-Settlement and Present Diversity of the Forests of Central Ontario. M.Sc.F Thesis, Faculty of Forestry and the Forest Environment, Lakehead University, Thunder Bay, Ontario, Canada, 78 pp.

Ecology of Hemlock (*Tsuga canadensis*) in Algonquin Provincial Park, Ontario and Ungulate Browsing

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We investigated size and age gaps in eastern hemlock (*Tsuga canadensis)* populations of Algonquin Provincial Park. Several hypotheses are proposed, each involving a period of high seedling mortality or limited seedling establishment. The hypotheses are seed predation, seedling establishment, hare browsing, ungulate browsing, stem exclusion and canopy suppression. We classified 216 randomly placed 0.04 ha plots by stand type, aspect, cut/uncut, lakeshore/non-lakeshore and deeryard/non-deeryard. All stems $\geq$ 5 cm dbh were recorded by: species, diameter, height, and age. All hemlock seedlings and saplings < 5 cm dbh were recorded by: height; age at ground level; percentage of seedling damaged by browsing; and whether hare or ungulate browsed. We measured 5159 stems $\geq$ 5 cm dbh from 25 species and 19,794 hemlock seedlings < 5 cm dbh. A gap was present in the age structure with a distinct scarcity of stems between 40 and 125 years of age. The ungulate browsing hypothesis had the most support, as the gap was most distinct in deeryard-non-lakeshore sites, and least distinct in non-deeryard-lakeshore sites. Past browsing by white tailed deer (*Odocoileus virginianus*) had limited hemlock recruitment in former deeryard areas, while moose (*Alces alces*) browsing appears to be limiting hemlock recruitment in upland areas and extending the age gap. There was little support for the other hypotheses. Sugar maple appears to be replacing hemlock, especially in areas with heavy browsing pressures.

We tagged 2000 hemlock seedlings in 1992 and monitored them for 5 years. Variables recorded included seedling leader growth, diameter at 10 cm height, height loss from browsing, percentage of the seedling damaged by browsing and mortality. Environmental variables measured include percent canopy closure and snow depth for one season. After five years, 8.5% for the seedlings were dead from browsing, decline, or physical damage from logging operations. Height growth increased with greater initial seedling height, and was greatest at 60% and least at 100% canopy cover. Moose browsed 11.9% and snowshoe hares browsed 1.7% of all seedlings annually. Mean height losses were 10% of a seedling's initial height. Of the seedlings browsed each year, 42% had not been previously browsed. At current browsing and growth rates, few saplings will be able to grow out of the reach of moose and recruit into the canopy, except for areas with low browsing pressure.

Influence of Landscape-Scale Forest Structure on the Presence of Pileated Woodpeckers (*Dryocopus pileatus*) in Central Ontario Forests

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The goal of this research was to investigate the influence of landscape-scale forest structure on the presence of pileated woodpeckers (*Dryocopus pileatus)* in central Ontario forests. Study sites were located in Algonquin Provincial Park. The presence of pileated woodpeckers was recorded along five kilometre transect lines. The area around each transect line was used for landscape analysis and represented 5 km^2. Landscape-scale structure analysis was conducted on the composition and configuration of pileated woodpecker habitat. The habitat was classified based on several methods and focused on the variations of the Pileated Woodpecker Habitat Supply Model (PWPHSM) for central Ontario. To determine which of the classifications best predicted the presence of pileated woodpeckers, logistic regression was run on the variable "percent of land (%LAND)" for each classification. The landscape structure of the best classification was further examined to explain the presence of pileated woodpeckers by entering all landscape-level and class level (FRAGSTATS) variables into a logistic regression procedure.

The relative densities of pileated woodpeckers in Algonquin Park averaged 0.27 breeding pairs per km^2 (SD = 0.146, range = 0.2 – 0.8). The preferred habitat classification was the best predictor of the pileated woodpecker presence. Total, used, and feeding habitats were less able to predict the presence of pileated woodpeckers. Core Area Density (CAD), Number of Core Areas (NCA) and Largest Patch Index (LPI) predicted pileated woodpecker presence better than %LAND. The final logistic regression equation using the CAD variable was:

$$\text{Probability (presence)} = 1/(1+e^{-(Y)}) \text{ where } Y = -1.5204 + 1.1039 * (\text{CAD})$$

The equation correctly classified 71.67% of the original data ($X^2 = 10.4493$, df = 1, p = 0.0012). The habitat supply model used to classify preferred nesting habitat was verified as an adequate tool for the management of pileated woodpeckers. The ability of the core area variable to predict pileated woodpecker presence supports consideration of the influence of edge effects on this species. Forest managers are also encouraged to continue to move toward spatial habitat analysis in management planning.

Response of Birds and Vegetation to the First Cut of the Uniform Shelterwood Silvicultural System in the White Pine Forests of Algonquin Provincial Park, Ontario

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The response of birds and vegetation to the first cut of the white pine uniform shelterwood silvicultural system was examined in Algonquin Provincial Park, Ontario. Bird abundances and vegetation cover were compared among stands that were logged during the period of 1970-1994 and mature stands with no recent logging history ("Old- cut"). Of 63 species recorded, seven showed a significant difference in abundance between 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 sparrow (*Zonotrichia albicollis*), chestnut-sided warbler(*Dendroica pensylvania*), and mourning warblers (*Oporonus philadelphia)* were more abundant in stands logged between 1970 and 1978, and between 1986 and 1994, where the canopy cover was the least. Stands logged between 1970 and 1978 had significantly greater amounts of understory vegetation than other years (due to the poor cutting techniques of the time), creating ideal habitat for veery (*Catharrus fuscescens)* and Canada warbler (*Wilsonia canadensis)*. Bird species richness was greatest in "Old-cut" stands and in stands logged between 1978 and 1986 (the two treatments with the greatest structural diversity), while 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.

Overall, there appeared to be little long-term effect of the first stage of this silvicultural system as bird abundances and vegetation cover recovered to the state of pre-cutting in 10-20 years. The effects of subsequent cuts may be more dramatic in the short and long term.

Autumnal Energetics and Habitat Selection of the Red Crossbill (*Loxia curvirostra*) in Algonquin Provincial Park, Ontario

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Red crossbills (*Loxia curvirostra*) are finches with uniquely crossed beaks for acquiring seeds from conifer cones. They occur in southern boreal forests and in the Great Lakes-St. Lawrence and Acadian forest regions (Cadman et al. 1987, Erskine 1992), where they are most common in pine-dominated habitats, particularly white pine (*Pinus strobus*) forests (Benkman 1987 a,b, Lawrence 1949). Red crossbills were observed in Algonquin Provincial Park in September and October 1998. Because of high seed intake rates due to plentiful white pine cones, birds were able to meet daily energetic requirements while foraging for only 7% of the day. The appearance of fledglings suggested that breeding had taken place. Energy costs were estimated in order to determine pine seed requirements for reproductive activities. Fledged young were energy costly to parents, but the nestling period was also crucial in terms of overall energy required. Surveys were also conducted to determine use of interior and roadside stands of mixed-low (40% pine); mixed-high (40-70% pine); and pinery (>70% pine) types. Red crossbills did not use mixed-low stands, and used mixed roadside buffer strips almost twice as much as any other stand category. They foraged more in roadside buffers than interior stands, but only if buffers were mixed ($p=0.07$, $n=23$). There was no significant difference in crossbill numbers between pineries and mixed-high stands ($p=0.30$, $n=23$). Our data also showed a weak but significant positive relationship between number of cones and number of crossbills in a given stand ($r=0.35$, $p=0.097$, $n=23$). Thus, we speculate that in years of cone abundance, a threshold of available seeds is surpassed in various stand types such that crossbills can successfully meet their daily energy needs with little time actually spent foraging.

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Benkman, C.W. 1987a. Food Profitability and the Foraging Ecology of Crossbills. Ecological Monographs 57(3): 251-267

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Comparison of Forest Bird Populations in Algonquin Park: the 1950s versus the 1990s

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The focus of this paper is to examine changes in populations of bird species from the early 1950s compared to the mid 1990s in contiguous, old-growth forest habitats. This paper also examines plant-bird community dynamics to determine if long-term changes in bird populations have altered the community organization. The data collected in this study represent one of only a few long-term studies of bird population dynamics in large, continuous, old-growth forest habitats in North America. These types of data provide crucial evidence for scientists attempting to document changes in neo-tropical migratory bird populations.

My research compared patterns of change in the 1952-53 and 1995-96 breeding bird communities in large expanses of contiguous, old growth forest habitats. I repeated seven breeding bird censuses in Algonquin Provincial Park, Ontario that were originally conducted by N.D. Martin in 1952-53. Vegetation surveys were also repeated in each of the breeding bird plots. The analysis of the differences between breeding bird and tree communities examined the four principal forest habitats for Algonquin Park: 1) maple-beech (*Acer-Fagus grandifolia*); 2) birch-aspen (*Betula-Populus*); 3) eastern hemlock (*Tsuga canadensis*); and 4) black spruce (*Picea mariana*). Analyses demonstrated that there were no major changes in tree species composition or structure in any of the four forest habitats. Additionally there were no statistically significant changes in the populations of 22 neo-tropical migrant, 12 short-distance migrant, or 7 resident species of breeding birds in old-growth forests of Algonquin Park.

My research provided no evidence that circumstances away from the breeding grounds, such as tropical deforestation, have had any effect on the bird populations of Algonquin Park. Population declines were not observed in the three groups of bird species (Neo-tropical migrant, short-distance migrant, and resident). Additionally, results demonstrated that the relationship between the bird community and the structure and composition of the forest were uniform in 1952-53 and 1995-96. These combined results provide strong evidence that the factors limiting bird abundance were not related to wintering grounds.

Effects of Selection Cutting on the Diversity and Abundance of Birds in Hardwood Forests of Algonquin Provincial Park

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We examined the effects of selection timber harvests of various ages (0–10, 11–20, 21–30, and >40 years old) and the supply of wildlife trees (scattered conifers, mast trees, and supercanopy trees) on bird assemblages in 96 mature sugar maple (*Acer saccharum)*–yellow birch (*Betula alleghaniensis)*–hemlock (*Tsuga canadensis)* forest stands in Algonquin Park, Ontario, during 1992, 1993, and 1995. Species richness and total abundance of birds did not differ among cut classes. However, canonical correspondence analysis (CCA) suggested significant differences in bird communities among all cut classes, except for 11-20 versus 21–30 cut classes (Monte Carlo bootstrap test, CCA). Log-linear analyses suggested that the abundance of 10 species changed as a consequence of selection cutting. Blackburnian warbler (*Dendroica fusca)*, blue-headed vireo (*Vireo solitarius*), brown creeper (*Certhia americana*), least flycatcher (*Empidonax minimus)*, and ovenbird (*Seirus aurocapillus)* were less abundant in cut forest, whereas chestnut-sided warbler (*Dendroica pensylvania)*, mourning warbler (*Oporunus philadelphia)*, Nashville warbler (*Vermivora ruficappilla)*, rose-breasted grosbeak (*Phecticus indovicianus)*, and ruffed grouse (*Bonasa umbellus)* were more abundant in cut stands. Based on log-linear regression analyses, the abundance of Blackburnian warblers, black-throated green warbler (*Dendroica virens)*, and blue-headed vireos was significantly related to the density of scattered conifers, the abundance of rose-breasted grosbeaks was related to the density of mast-producing trees, and the abundance of Blackburnian warblers, black-throated green warblers, brown creepers , and ovenbirds was related to the density of supercanopy trees (60+ cm dbh). Our modelling suggests that some of the impacts of cutting may be reduced as hardwood stands become regulated and a higher residual basal area is maintained. However, some species, such as ovenbirds and chestnut-sided warblers, may still be less or more abundant in cut stands. Current guidelines for the retention of scattered conifers appear to be adequate for most species, but guidelines for supercanopy trees may be too low. Our results provide an inconclusive evaluation of the effectiveness of current mast tree guidelines.

Decline of the Gray Jay (*Perisoreus Canadensis)* in Algonquin Park

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The gray jay (*Perisoreus canadensis)* is a non-migratory bird of North American boreal and sub-alpine forests dependent on stored food for its winter survival and late winter breeding. As indicated by the occupancy of 44 territories in Algonquin Park, the local gray jay population declined by 40-50% between 1970 and 2000. There was complete disappearance of breeding pairs on nine territories dominated by hardwoods and lesser declines (25-35%) on 35 territories dominated by lowland forests of black spruce (*Picea mariana)* or upland coniferous forests of white spruce (*Picea glauca)*, balsam fir (*Abies balsamea)*, and white pine (*Pinus strobus)*. Concurrent with these declines, there has been a trend towards earlier breeding and reduced reproductive success. We hypothesize that earlier breeding may be associated with a trend toward milder winters and that lower reproductive success may be due to increased perishability of stored food. The gray jay may be an example of a species whose persistence is threatened by global warming along lower latitude or lower elevation edges of its range.

Response of Nest Predator Guilds and Avian Productivity to Selection Cutting in Algonquin Provincial Park, Ontario

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The effects of even-aged forestry practices on birds are well-known, but only two studies have been published to date on the effects of selection cutting on birds. For my undergraduate thesis (1998), I looked at how single-tree selection cutting altered the physical structure of Algonquin's tolerant hardwood forest, and how those changes led to corresponding changes in the forest songbird community. It remains uncertain whether edge effects (i.e., increased nest depradation rates) exist in contiguously forested landscapes. Most work to date on this question has been based on artificial nest studies, making it essential to determine the accuracy of artificial nest studies before extrapolating results to real nests. It is currently required under the Crown Forest Sustainability Act (RSO 1995) that all forest management practices in Ontario's Crown forests be 'ecologically sustainable'. For the past two summers (1999 and 2000), I have expanded on my previous research to evaluate the ecological sustainability of single-tree selection cutting in terms of avian productivity. Specific objectives were: 1) to determine if changes in nesting success and composition of potential nest predator guilds occur as a function of the selection cutting systems; 2) to determine if functional edges are created by the selection cutting system in a contiguously forested landscape ('true' edges: along logging roads, 'psuedo' edges: perforation of canopy); 3) to identify key nest-site habitat characteristics for six bird species; and 4) to determine the availability of these nest-site-specific characteristics in stands at various temporal stages in the selection cutting rotation. Data analyses are incomplete at this point. This talk will present an outline of research activities conducted and present preliminary results.

Coarse Wood in Lake Littoral Zones

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Ontario has an estimated 260,000 lakes, many of which have at least some forested ecotone. Many of the less developed shorelines of these lakes have large quantities of coarse wood in the littoral zones. Aquatic coarse wood provides valuable habitat for a variety of aquatic and terrestrial flora and fauna. We lack specific knowledge of the ecological properties, input rates and residence times of littoral zone coarse wood, which makes it difficult to make resource management decisions about forest lake ecotones that are sustainable.

Eastern white pine (*Pinus strobus* L.) and eastern hemlock (*Tsuga canadensis* L.) are two of the most common tree species contributing coarse wood to the littoral zones of lakes in central Ontario. We mapped and described white pine and hemlock coarse wood in four central Ontario Lakes, Swan, Scott, Dividing, and McCullock, and used dendrochronology to estimate residence times using cross-sectional samples collected from logs. The mean littoral zone residence time for hemlock is 147 years and for white pine, 271 years. The maximum estimated residence time was nearly 700 years for white pine. White pine coarse wood generally has more surface area above the water line than hemlock. It is more likely to be oriented parallel to the shoreline, and has more terrestrial flora and faunal diversity. These factors may make it more valuable as long-term aquatic habitat than hemlock.

Insect and Microclimate Responses to Selection Cutting in Algonquin Hardwood Forests

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We measured microclimate and vegetation gradients at 10 m intervals along a 100 m transect perpendicular to road and trail edges in three logging treatment types(<2 yrs ago; 2-5 yrs ago; and 15-20 yrs ago) and in wilderness designated regions in the hardwood forests of Algonquin Park. Strong microclimate gradients were found for soil moisture, with soil moisture increasing as a function of distance from the road/trail edge, especially in the logged treatments. Other microclimate features including air and soil temperature and light intensity varied significantly among treatments but not as a function of distance from the edge. Vegetation gradients were strong with decreases in herbaceous and 1-2 m cover class, and increases in ground vegetative cover and 2-5 m cover class as a function of distance from the edge. Strong treatment effects occurred in 5m+ (canopy) cover, as expected after removal of canopy trees. There were no significant differences in canopy cover between 15-20 year old stands and wilderness zone stands. In a separate but related study we found strong treatment effects on the average number of carabid beetles, with a 50% reduction in numbers in recently logged stands. We explain these reductions as responses of the invertebrate communities to major alterations in forest microclimate especially 1-5 years after selection logging. Carabid beetle biomass was not significantly different in 15-20 year post-cutting stands and wilderness zone stands.

Forest Succession, Disturbance, and the Sustainability of Beavers (*Castor Canadensis)*

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Theory suggests that territorial species should share many of the same dynamical characteristics as metapopulations, including: asynchronous local dynamics; potential for stochastic extinction of the population when rates of successful dispersal fall below mortality risk; and critical importance of the ratio of suitable to unsuitable habitat for long-term persistence. I tested these propositions on a population of beaver (*Castor canadensis*) in Algonquin Provincial Park, Ontario, which has been continuously monitored over 11 years. My results showed that the total population was considerably less variable than local abundance at 14 beaver colonies, due to asynchrony among local populations. This suggests that local ecological interactions were more important in determining year-to-year variation in beaver numbers than broad-scale environmental processes, such as weather. 20% of the local colonies were never abandoned over 11 years, although there was considerable turnover among adults. Offspring production exceeded adult abundance at five source colonies, which did not quite compensate for negative net production at nine sink colonies. These observations were consistent with predictions of spatially-structured models of territoriality, incorporating local variation in habitat suitability. Mean colony size and probability of recurrence from year-to-year were associated with local food availability, indicating that trophic interactions were important in determining local population dynamics. The beaver population in Algonquin declined steadily over the study period however, suggesting that spatial and demographic processes were insufficient to stabilize abundance over time. This is consistent with predictions of spatially-structured models of territoriality in which suitable and unsuitable habitats are interspersed. I hypothesize that long-term decline in habitat suitability is induced by acceleration of woody plant succession due to selective foraging by beavers. Management actions to ensure sustainability of beavers should include some source of disturbance, natural or otherwise, to restore early successional stand characteristics.

Long-term Fluctuations of Small Mammals in Upland Habitats in Algonquin Park

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Since 1952, small mammals have been trapped on the same standard traplines (10 stations of 2 traps each at 10 m intervals) and 2001 will be the 50th year of this study. Such long-term studies are useful in monitoring abundance and diversity, and in testing hypotheses regarding ecological and demographic patterns. Hypotheses can be tested either by direct analysis of the data, or by using such studies to generate hypotheses that can be tested by specific experiments. Some basic patterns in abundance and diversity of the eight most common species of small mammals will be discussed, particularly in relation to weather and mast production. As well, long-term trends will be viewed in the context of 50 years of undisturbed growth of the mixed and hardwood forests of southern Algonquin. Lastly, an argument will be made that long-term studies should be an important priority of our provincial parks to enhance both understanding and conservation of biodiversity.

Multiple Landscape Scales and Winter Distribution of Moose (*Alces alces*) in a Forest Ecotone

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Winter distribution and abundance of moose (*Alces alces*) were studied in relation to habitat use and habitat disturbance at local and regional landscape scales in Algonquin Provincial Park, central Ontario. Thirteen years of government aerial population survey data (1976-1988) were supplemented with spring pellet surveys of eight habitats to determine differences in forest species composition, winter habitat utilization, and habitat disturbance by spruce budworm (*Choristoneura fumiferana*) and non-clear-cut logging. At a local scale (< 100 km^2), moose select closed canopy habitats in winter. Hemlock (*Tsuga canadensis*) provided important winter habitats for moose in the Algonquin transition-zone ecotone; hemlock was disproportionately chosen in both 'high' and 'low' density aerial survey plots, and occurred in greater amounts in 'high' density plots than those in 'low' density plots ($p < 0.05$). At larger, regional scales (>1000 km^2), moose are selecting areas of canopy disturbance. Plots impacted by logging of more than 33% of their area supported more moose than plots with less than one-third of their area logged ($p < 0.05$). Similarly, spruce budworm defoliation created more browse material and consequently contained more moose in severely affected areas, but plots in moderately defoliated areas require additional logging activity to produce comparable amounts of browse and moose use. A methodology of combined pellet survey and aerial survey data appears to identify habitat requirements at different landscape scales.

Reference:

Forbes, G. J.; Theberge, J. B., Multiple Landscape Scales and Winter Distribution of Moose, Alces alces, in a Forest Ecotone. The Canadian Field-Naturalist, 1993 vol. 107, no. 2 (April-June), page 201,

Landscape Modeling of Moose Habitat in Algonquin Park

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A landscape planning model, BOREAL was used to examine the interactions between timber production and moose (*Alces alces* L.) habitat for a 5000 ha area in Algonquin Provincial Park, Ontario. The model projects outcomes of forest management alternatives in terms of future habitat conditions. The system is flexible and can be adapted to a variety of forest-planning scenarios.

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Effects of Selection Logging on Amphibian Diversity and Abundance in Shade-Tolerant Hardwood Forests of Algonquin Provincial Park, Ontario

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Despite the widely acknowledged importance of amphibians in forest ecosystems, they are rarely included in forest management plans. Very little is known about the effects of, or amphibian response to, timber management. To determine whether, and if so, how, selection logging affects amphibians in shade-tolerant hardwood forests, I compared amphibian habitat concurrently with amphibian diversity and abundance in managed (logged) and unmanaged (unlogged) forest stands in Algonquin Provincial Park, Ontario. Selection logging significantly altered aspects of shade-tolerant hardwood forest habitat on which amphibians are known to depend. However, with the exception of American toads (*Bufo americanus*) that were more abundant in managed stands, the overall diversity and abundance of amphibians did not differ significantly between managed and unmanaged areas. Therefore, I concluded that selection logging does not alter hardwood forest habitat to the degree that it negatively affects amphibian diversity or abundance. Implications of this conclusion are discussed.

Ecology of the Wood Turtle, *Clemmys insculpta*, in Algonquin Provincial Park

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A population of wood turtles (*Clemmys insulpta*) was studied from May to October 1999 and from April to September 2000 in the eastern part of Algonquin Provincial Park, Ontario. This study expanded on previous work conducted from 1986-1989 in the same general area. The general goal was to investigate the demography, habitat selection and home range of Algonquin wood turtles, and to examine how these characteristics differ from other wood turtle populations. Eighty-two turtles were found during the latest study: 45 females, 20 males and 17 juveniles. Adult sex ratio was 2.25:1 (females:male). Thirteen nests were found in 1999 with an average clutch size of 9.8 eggs. Overall hatching success was 75%, and 69% of the nests were parasitized by fly maggots. Ten nests were found in 2000, but eggs had not hatched by the end of August. Radio-telemetry was used to track 15 turtles in 1999 and 25 turtles in 2000. Turtles selected a wide variety of habitats, including alder swale, mixed forest, coniferous forest, water, roads, and open meadows. The average home range size, calculated using the minimum convex polygon method, was 39.5 ha in 1999 and 34.8 ha in 2000. These are the largest average home ranges ever reported for wood turtles, and this factor may have significant implications for the conservation of this vulnerable species. For example, wood turtles may suffer more than previously expected from habitat fragmentation through practices such as road construction.

Forest-Wildlife Research in Algonquin Park - the 90s: Closing Remarks.

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To begin, I'd like to set out some context for these closing remarks. This really means admitting to those aspects of my background and my biases that influence how I perceive forest-wildlife research conducted in Algonquin Park during the 1990s fitting into "the big picture". There are perhaps two areas, broadly related to each other, which connect directly to what has been discussed here these last two days.

The first of these was an invitation to participate with OMNR personnel over several months in the mid-1990s on a response to the terms and conditions, particularly 80 and 81, of the Class Environmental Assessment (EA) for Timber Management (OEAB 1994), and to observe the evolution of the government's response to the EA through subsequent policy initiatives (OFPP 1993), law (RSO 1994) and, most recently, the draft Fire Simulation Guidelines. The EA charged the OMNR to "... undertake *scientific* studies to assess ... effects of timber management on ... habitat ... [and] monitor [wildlife]" (my italics). New provisions in policy, law and management guidelines, since the 'timber EA', state that forest management shall emulate *natural* disturbance (again, my emphasis).

The second of these was an invitation to serve on a federal review panel that examined whether and how well Parks Canada was achieving its mandate – long embedded, in this case, in policy and law – to maintain the ecological integrity of national parks (Parks Canada 2000). Ecological integrity, after Karr and Dudley (1981), Karr (1981,1991), and the USEPA (1993) is defined as " ... species composition, diversity and functional organization representative of *natural* habitats of the region...".

Together, these exercises profoundly reinforced for me the strong need for parks and other protected lands to serve a role as *natural* ecological baselines (controls, reference states) that would enable *scientifically* credible analyses of the suspected effects of human activities (eg., hunting and/or habitat alteration by forestry, mining, agriculture or urban development) carried on outside their boundaries (Arcese and Sinclair 1997, Nudds 1998,1999) and how that is linked tightly to the notion of sustainability of renewable resource economies in intervening 'working landscapes' (Nudds et al. 1998).

"Scientific" means, to me, the hypothetico-deductive method, which for all its detractors, is still the underpinning of modern Western science and has been vigorously defended as the best means to accumulate reliable knowledge and discard unreliable knowledge. Use of the 'H-D method' has been advocated, in particular, in the arena of renewable resources management (Romesburg 1981, Nudds and Morrison 1991, Lancia et al. 1993, 1996) and specifically for fisheries, forest and wildlife management in Ontario, consistent with an adaptive management approach (MacDonald et al. 1999). "Scientific" implies that, given observations about a system, such as wildlife-forest relations, hypotheses are developed to guide fieldwork about *why* those observations form the patterns that they do. There should be corresponding predictions, manipulative (or mensurative) experiments with controls (or reference states) to evaluate the predictions, and adequate temporal and spatial replication. Studies that lack these characteristics, and rely solely on reporting observations and patterns, may be perfectly good natural history, but natural history studies by themselves are not scientific in the sense I use the term. Further, such studies are highly vulnerable to the pitfalls of retroductive logic when used as a basis for inferring courses of action for management (Romesburg 1981).

"Natural" means to me, as it does to many people, the absence of significant change to environments caused by humans. Thus, it is essential, in order to *scientifically* evaluate the effects of human activity in landscapes where it is conducted, to have landscapes where such activities are not conducted for comparison (Arcese and Sinclair 1997, Nudds 1999:184). In practice, however, from an experimental perspective, this doesn't have to mean landscapes with no human influence, but rather, the absence of the human factor of interest. In fact, from a strictly experimental perspective, it might be desirable to keep all else equal between two areas that are contrasted – say, for the effects of timber management – such as acid deposition, climate change, and other factors that might potentially confound the "timber management" experiment. This points to the fact that, at these scales of contrast, it is seldom possible to have perfect experimental controls, but this should not be an excuse for not trying. Even a constrained "experiment" to test an hypothesis leads better to the accumulation of reliable knowledge than no experiment at all (Nichols 1991). In the context of managing forests to emulate the effects of natural disturbance, thinking like this enables the development of adaptive management protocols to test policies. The policy to emulate natural disturbance, for example, can be restated as a scientific null hypothesis: that landscapes managed for timber will not be different in ecologically significant ways from landscapes not managed for timber, that is, inside and outside of protected areas.

Thus, I 'scored' 18 abstracts of papers and the oral presentations presented over two days with these 2 'big-picture' ideas in mind: (1) the extent to which characteristics of sound "experimental" science were evident in each study and (2) the extent to which the park served in the study as an ecological benchmark for the effects of timber management.

With respect to 'big-picture' idea number one, only half (8/16) tested hypotheses. And I was liberal here, by assuming that hypothesis-testing was implicit in any study that contrasted 'treatments' with 'controls' for some factor of interest, though, in fact, only half (4/8) of those mentioned the word 'hypothesis' in either the abstract or the talk itself.
Of the half that didn't test hypotheses, three quarters (6/8) committed errors of retroductive logic, that is, confused speculation (an a posteriori hypotheses) with explanation about why patterns were observed. The rest were natural history.

Fifteen studies were reasonably well replicated in time: with 5 studies spanning < 10 years (most much shorter due to the "thesis effect"); 4 studies, 11-20 years; 3 studies, 21-30 years; 2 studies, 31-50 years; and 1 study, 100 years. However, only five of the studies comprised continuous data; the others were "then vs. now" contrasts. Of 17 studies, eight were reasonably well replicated spatially, seven had no replication, some because the nature of the study really didn't demand it. Last, two studies were pseudo-replicated, that is, subsamples from a few locations were treated as if they were independent replicates in statistical tests.

With respect to the second 'big-picture' idea, most of the studies were, as billed, about forest-wildlife research, generally speaking; those that were about *forestry*-wildlife relationships were fewer. Only one study referred to Algonquin Park as an ecological baseline for the effects of activities outside of it, in an attempt to distinguish between competing hypotheses about whether the apparent population declines of some neo-tropical migrant birds might be due to events on or away from breeding areas. The rest of the studies about forestry effects did well to compare areas with and without selective logging, but these contrasts were all internal to the park. These were useful studies, and their findings are, of course, probably transportable across park boundaries. However, the park-centred nature of most of the studies suggests that there is some distance to go yet to employ Algonquin Park as a baseline for studies of factors we suspect to be problematic for species outside of protected areas. Enhancing this role might be a factor for consideration when shaping park research policy in the future.

By and large, it seems that the overall conclusion that can be drawn about forestry *in* the park, to the extent that it has been investigated, is that there is little evidence of ecologically significant negative effects. In contrast, there is considerable angst about the effects of other kinds of timber management (and other activities) *outside* of protected areas, like Algonquin, and this is perhaps where some significant attention could be paid to further enhance the use of protected areas as ecological baselines for evaluating those effects.

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Note: 1999 PRFO Proceedings contained 62 papers, commentaries and abstracts; and 1998 PRFO Proceedings contained 47 papers, commentaries and abstracts. In addition, approximately 10 posters were presented at each conference. We estimate in excess of 50 papers, commentaries and abstracts for the 2001 proceedings. The combined SAMPAA/PRFO 2000 proceedings will likely contain 125 papers. Information about the proceedings, including individual papers, commentaries and abstracts can be secured from the proceedings themselves or the Heritage Resources Centre, University of Waterloo (hrc@fes.uwaterloo.ca).