Evaluating forest management at meaningful scales: A proposed national program to monitor boreal forest birds

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Abstract

Programs to monitor the effects of various industrial practices are often small scale, short lived, and fail to meet their objectives for various well documented reasons. Many monitoring programs detect minor changes in site-specific practices. Rarely are they able to evaluate changes in management. These programs do not contribute well to population management of migratory birds; management of those populations must be conducted at a range of spatial scales. Very large regional and national scales are critical. For various social, legal, and scientific reasons, a national scale, systematic, and rigorously designed monitoring program for birds is needed. This article describes suggested goals and objectives for such a program, and the principles which should guide the program's design. Partnerships with provinces, industry, and other groups will be crucial. The program would have statistically defensible monitoring goals and would strive to cover the forested landscape with a systematic sampling plan. The program would be developed in consultation with all major stakeholders. Once active, the program would be in a unique position to compare and contrast various landscape units across regions, provinces or other areas of interest with different management and resource use patterns and intensities. This approach would enable Canadians to address issues of forest management at scales relevant to bird populations. Such a program could also form the foundation for monitoring by many industrial players, avoiding an ad hoc approach of multiple, small, disconnected programs that draw crucial resources.

Introduction

On the face of it, "monitoring biodiversity to ensure conservation goals are being met" sounds easy. Methods for monitoring individual species of plants or animals, species assemblages or their habitats are readily available in the scientific literature. Many governments and industries are required to, and report to be, monitoring for the purpose of meeting conservation goals.

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Citation: C.S. Machtans and M.R. Norton. 2007. Evaluating forest management at meaningful scales: A proposed national program to monitor boreal forest birds. Paper presented at the "Monitoring the Effectiveness of Biological Conservation" conference, 2-4 November 2004, Richmond, BC. Available at: http://www.forrex.org/events/mebc/papers.html

Notes: This paper has been peer reviewed prior to posting.

However, once a monitoring program begins, participants often realize the limitations of everything from the spatial and temporal scales of the study to the amount of funding available to have a successful monitoring program. Many also realize the statistical complexities of properly analyzing simple count data long after the monitoring program is underway or complete. The disappointing phrase “Further study is needed to ....” is the traditional ending to a report or manuscript.

Not all monitoring programs are doomed to fail. However, many programs do ultimately fail to meet their primary objectives (Reid 2001) and contribute little to conservation of biodiversity. Reid (2001) examined 30 flawed monitoring programs and found that many failed for deceptively simple reasons. Seventy percent of those failures had fundamental design problems, and 50% had procedural problems. The four most common issues were problems with field staff, inability to measure the parameter of interest, data were not analyzed in time, and/or the study was too short (Reid 2001). These are not trivial problems. Noon et al. (1999) stated that a review of existing monitoring programs in American national forests revealed that programs often existed in name only. For existing programs, many have poor funding, have little foundation in ecological theory, or fail to follow the fundamental statistical principles of sampling and estimation. Programs also fail because many have little logic to support selection of indicators, there is no necessary understanding of causation, trigger points for decision making are absent, and direct links to a decision making process that alters practices are absent (Noon et al. 1999). Success of monitoring programs is often measured in metrics such as number of samples, years of sampling, or the number of resulting publications and reports. In reality, a monitoring program is only truly successful to the extent that it provides information for management decisions, and provides warnings of ecosystem degradation (Noon et al. 1999).

Many of the reasons monitoring programs generally fail are reasons that make monitoring populations of migratory birds in the boreal forest difficult. Conservation decisions should be based on studies that provide insight into the population of interest. Yet, to cite an example of how difficult that task is, consider one of nearly 300 species of birds that breeds in the boreal forest. The range of the Bay-breasted Warbler stretches across northern Canada from the Northwest Territories to the Maritimes (Figure 1). The first-ever population estimate for the species is 3,100,000 individuals and was only recently published (Rich et al. 2004). The accuracy of this estimate is stated as being only “fair”, with the expected true value to be within an order of magnitude (between 300 thousand and 30 million). The density of Bay-breasted Warblers can vary between none in unsuitable habitat to four pairs per hectare in ideal habitat with a high food supply (Williams 1996), varying non-systematically across its range. Even if the bird was uniformly distributed across its range, a monitoring program that tracked only 10% of the national population would have to cover at least 30 million hectares, an area slightly less than the entire forested portion of Alberta. How can any monitoring plan based on a forest management area, conservation area or other relatively small area collect any meaningful conservation data on such a widespread species? Recent research (Toms 2004) demonstrates the difficulty of finding an appropriate (regional) spatial scale to study songbird populations.

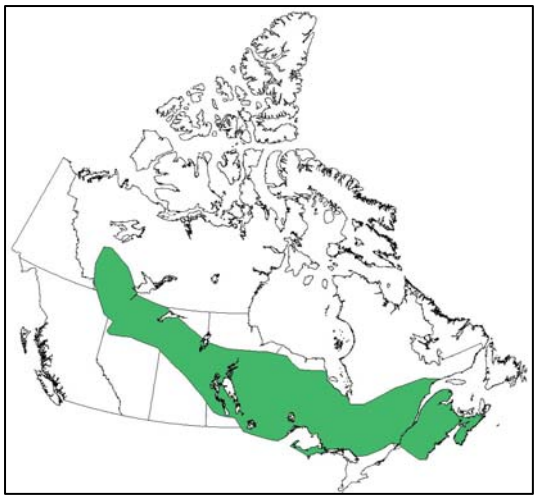

Figure 1: The summer range of the Bay-breasted Warbler (Ridgely et al. 2003)

Thus, in the context of birds and the boreal forest, “monitoring biodiversity to ensure conservation goals are being met” is anything but easy. It is difficult to collect the necessary data on useful spatial and temporal scales, to design and run a sampling program in remote areas, and to establish causal relationships without ancillary data and/or hypothesis testing experiments. Further, decisions that would benefit or interfere with conservation of such widespread species are shared between countries, multiple levels of governments, private landowners, and industry. Finally, funding a monitoring program large enough to collect the data necessary to manage populations of many boreal breeding species is beyond the means of any one organization, private or public.

A proposed national program is described that would provide the data that can lead to meaningful conservation decisions for birds breeding in the boreal region. A program of this scope would be able to compare and contrast different land use and management practices across regions, provinces, or ecological boundaries. Such a program would only be possible by building partnerships with all levels of government and all industrial sectors active in the northern forests.

Birds and the Boreal Forest

The boreal region is the world’s largest terrestrial biome, extending across Canada, northern Europe, Russia, and Alaska. It is the largest forest region in Canada, accounting for half of Canada (5.2 million square kilometers) (Figure 2). It contains a broad mix of deciduous and coniferous forest, but nearly 30% of the region is covered with diverse wetlands such as bogs, fens, and lakes.

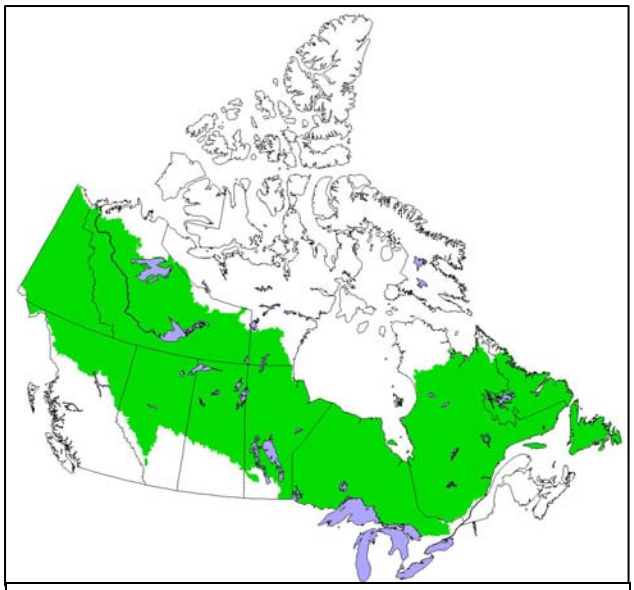

Figure 2: The extent of boreal forest in Canada as defined by ecozone boundaries

The boreal region holds the highest diversity of breeding bird species of any forest region in North America. Nearly 300 species breed in the region each year, producing 50% of Canada's breeding birds (Blancher 2003). In summer, the region is home to an estimated 1.5 to 3 billion landbirds, 12 to 14 million waterfowl, and uncounted millions of shorebirds and waterbirds.

Society places tremendous demands on resources in the boreal region. More than one third of the region has been allocated to industrial development. Forestry, agriculture, oil and gas development, hydroelectricity, and mining all have impacts on the boreal forest ecosystem, and the cumulative effects of these multiple activities are largely unknown. The current level of impact varies across Canada. In Alberta, 86% of the boreal forest has been impacted, whereas in Yukon and Labrador the majority remains intact (Lee et al. 2003). However, in all areas of Canada, the trend is towards rapidly increasing development pressure. Acid precipitation is a significant concern, particularly in the east. Overarching all will be the effects of climate change, which is expected to be greater in more northerly regions.

Domestic and international public attention is increasingly directed at Canada's boreal region (e.g., National Geographic (June 2002), Canadian Geographic (January/February 2004), and the New York Times (23 September 2003)). Numerous environmental non-governmental organizations are campaigning aggressively in support of boreal conservation, several with a particular focus on birds (Forest Ethics 2004; see also http://www.borealbirds.org/). Demands for "green" timber certification by consumers are influencing industrial forest companies to move toward more sustainable practices. Diverse partnerships are highlighting the importance of the boreal region, and promoting its conservation and sustainable use (for example, the Boreal Leadership Council, http://www.borealcanada.org). Progressive management systems, supported by science and monitoring, are required to meet these challenges, a fact recognized by a special committee of the Canadian Senate (Senate Subcommittee on the Boreal Forest 1999).

Developing a monitoring program that can address these issues requires cooperation on a massive scale. The Canadian Wildlife Service of Environment Canada is in the early stages of

assessing interest and involvement from potential partners amongst government, industry, and environmental organizations. This article provides the background and rationale for developing a national-scale monitoring program. It also describes some of the basic goals and objectives envisioned in such a program, to assist in seeking input from partners to further develop the goals and objectives to meet the needs of a diverse group of stakeholders.

The Proposed Program

Guiding Principles

An Integrated Approach Across the Boreal
The proposed program would work to improve monitoring for species in all bird groups (landbirds, waterbirds, waterfowl, and shorebirds) and all habitats. Efficiencies would be realized by conducting monitoring for all types of birds in a coordinated manner. This would likely require that the program be composed of multiple new surveys, as not all birds can be counted effectively with a single technique.

Existing survey programs would be integrated to the extent that they contribute information on boreal birds. Key examples of such surveys are the Breeding Bird Survey, the US Fish and Wildlife/CWS Spring Waterfowl Survey, migration monitoring, and MAPS (monitoring avian productivity and survivorship). Examples of other regionally significant programs that could contribute include the Ontario Forest Bird Monitoring Program, the Black Duck Joint Venture, the Alberta Biodiversity Monitoring Program, and provincial bird atlases and checklists. Integrating the data from many disparate sources will not be easy, but is as important as conducting new surveys.

Monitoring would be integrated and comparable across the boreal region of Canada with the proposed national program. Approaches and designs would also be linked with adjacent areas, such as the boreal forest in Alaska and transitional forests in eastern Canada. Only with a nationally standardized design, consistent methodology, and comprehensive analyses and reporting can essential questions be answered about such issues as cumulative effects, regional variation, and climate change.

Further guidance can be derived from national or continental conservation plans which have been developed for each bird group. Other frameworks provide conceptual guidance for developing and integrating bird monitoring programs (e.g., Canadian Landbird Monitoring Strategy; North American Coordinated Bird Monitoring Plan (in development)). All of these documents point to the importance of developing bird monitoring in boreal regions.

Science Support for the Management of Human Impacts
The purpose of the proposed program would be to identify changes in bird populations and habitats, and to link those to changes on the boreal landscape. The program should be designed so as to be able to scientifically answer questions about the causes of observed changes in bird populations. This knowledge would provide a foundation on which to base recommendations for management action to achieve conservation goals. Under this model, monitoring and research activities would be closely integrated. Significant effort would need to be directed to reporting of results in a manner which facilitates their use by resource management decision-makers. This last point cannot be overstated and, as noted earlier, is the only meaningful result of a monitoring program.

A Co-operative Approach
Monitoring birds across the vast and remote boreal region cannot be achieved by any single group or agency. A successful program of this scale requires a multi-partner approach, with input and ownership by all. The full range of interests must be represented to ensure relevancy and applicability of results.

Major Goals and Objectives

There are four over-arching management concerns that would be addressed by the proposed monitoring program. The first of these, status determination and priority setting, is a primary enabler of avian conservation work. The other management issues are of broad significance to biodiversity conservation, but for which birds can serve as effective indicators.

Sound scientific information is required to ensure that conservation efforts are directed at the right priorities and are effective. *Knowledge of the status and trends of bird species* is the essential foundation for all conservation planning and action. This information also provides the basis for setting objectives for populations and habitats, and the evaluation of whether those objectives are being met. Species at risk which may require targeted action can be identified.

Monitoring data is key to *sustainable management of natural resources by adaptive management*. Enhanced information will be required to manage increasing development in the boreal forest across Canada. The development of monitoring systems has lagged behind that of the management systems which monitoring supports. Monitoring enables the feedback loop that is crucial to assessing success or failure of management actions.

Understanding the *cumulative impacts of multiple developments* is one of the most challenging aspects of environmental assessment practice. Practitioners must assess the likely impacts of existing, proposed, and likely future developments, and recommend mitigative measures. Recommendations are routinely made for follow-up programs, such as monitoring, to determine the accuracy of the original assessment, but these are difficult to implement at scales large enough to address cumulative effects.

The *biological effects of climate change* will be evident only at the very largest of scales. Birds may provide a signal of global climate change in several ways. Changes in distribution, abundance, or phenology which could result from changing climate may manifest over long time periods and at large scales. The detection and interpretation of any such changes will only be possible through a sufficiently large scale monitoring program.

There are two strategic criteria that will be crucial to the success of the proposed program. Firstly, monitoring results must be effectively integrated into decision-making processes. This poses challenges to both current resource management systems and the monitoring program. Management systems must be responsive to new sources of information that might indicate deficiencies in the system. Likewise, the monitoring program must be able to report and communicate results in a manner relevant to decision-making at a range of scales. Secondly, the monitoring program must go beyond simple trend detection. Achieving enhanced understanding of the relationship of bird populations to human activities should be a fundamental driver of the program's design. Scientific questions about the impacts of resource development on birds at large scales must be integral to the program. The program should be able to assess the effects of different management practices or intensities in different areas across the boreal region. The

value of a program such as this lies in its ability to influence decisions, and will be successful only to the degree it achieves that end.

Proposed Technical Objectives

It is possible at this early stage to describe potential technical objectives of a Boreal Bird Monitoring Program. These relate to the list of target species for monitoring and the type and quality of data to be collected to achieve scientific and statistical defensibility. They are important to help define of the scope and scale of the proposed program.

The proposed program would cover species from *all four bird groups*: landbirds, waterfowl, waterbirds, and shorebirds. There are an estimated 233 species of birds that rely on the boreal forest (>10% of breeding or wintering range in the boreal forest; many more species breed peripherally in the boreal), most of them for their summer breeding season. The majority of these are landbirds (149 species), but shorebirds (27 species), waterbirds (27 species) and waterfowl (30 species) are also found in significant numbers. Most significantly, 92 species have >50% of their range within the boreal forest, and 24 species are resident in the region year-round. These are the species for which the boreal is absolutely crucial, and which the proposed program would likely emphasize.

A substantial number (131) of boreal species are not currently monitored to a level sufficient for conservation and management, even at the broadest scale across North America. None of the species is sufficiently monitored within the boreal region, with the exception only of a very few species at risk (e.g. Trumpeter Swan, Whooping Crane, Bicknell's Thrush).

The proposed program should produce count data that are *corrected for sampling and detection bias* as per current standards in the scientific community (IAFWA 2004). Calculations of breeding density (as opposed to relative abundance) are independent of the technique used to collect them. Therefore a combination of different types of counts (transects, point counts, area searches, etc.) could be used when appropriate and yield comparable estimates of density.

Measurement of *population trends* of birds breeding in the boreal region with sufficient statistical precision is central to the proposed program. A suggested precision target is to describe population trends such that declines of 50% over 20 years will be detected with 80% power and a significance level of 0.1 with a two-tailed test (Bart et al. 2004). Meeting this target would mean there is an 80% certainty that a 50% decline over 20 years would be detected, and that there is less than a 10% chance that a difference would be declared where there really was none.

Bart et al. (2004) used data from the Breeding Bird Survey to evaluate the trade-offs between magnitude of population decline, duration of survey, power, and significance level and their effects on the number of survey routes required (e.g., cost). Their recommended target is based on a balance between realistic expectations of both variance in the data and population declines, magnitude of detected trends that would provide meaningful information for managers, and cost factors. For example, while detection of population change of 25% would be preferable to the target of 50%, the 25% target would require nearly 6 times the sample size. The need for a similar statistical objective has also been recognized for waterfowl (NAWMP 2004), but additional analysis would likely be required to validate the target recommended by Bart et al. (2004) beyond landbirds.

Information on *demographic parameters* (productivity, recruitment, survival) over time is necessary to provide information on habitat quality, and to identify potential causes of observed changes in populations. Demographic monitoring can be conducted through locally intensive surveys at relatively fewer predetermined locations.

Measurements of *habitat* should be an important part of the proposed program. Habitat should be broadly defined, and may include measures of avian food resources such as arthropods. Quantification of habitat at large scales would be accomplished through interpretation of remote sensing imagery. Local scale habitat could be measured in the field in conjunction with bird surveys. Measurement of changes in habitat over time, including past disturbance history, will be important to be able to interpret changes in bird populations. It is also necessary to understand the relationship between bird population changes and human activities.

Partnerships and coordination with existing initiatives will be key to delivering on the habitat component of the proposed program. Consistency of approaches and methodologies (e.g. forest classifications) will be necessary to ensure comparability of data across jurisdictions. Of particular relevance is the National Forest Inventory program, a federally coordinated, provincially delivered program for the collection and management of forest inventory information. The sampling grid that has been established by the NFI provides one option for a sampling design for bird surveys.

Program Benefits

A national program would provide multiple valuable benefits to partners.

1. A monitoring program of the scale proposed herein would have the power to genuinely guide conservation and inform land use decisions with sound information.
2. Provide a means to measure the success or failure of management and conservation actions at the large scales relevant to bird populations.
3. Provide provincial and federal governments with a comprehensive avian biodiversity monitoring program that can address public concern over resource management issues and can allow those governments to help meet regional, national, and international commitments related to birds.
4. Provide industrial partners with a single-window solution to bird monitoring on lands where they operate. Clarity and certainty with regards to monitoring methods, design, data management, and reporting will be nationally concordant.
5. Provide on-the-ground habitat data to agencies responsible for forest management or other habitat-related management.
6. Provide a foundation for strategic scientific research, including identification of priority research questions.
7. Provide an early warning signal for large-scale environmental perturbations, such as climate change or regional industrial development.

Conclusion

A program such as a proposed National Boreal Bird Monitoring Program described here is necessary to improve our natural resource decision-making processes. Currently, insufficient information is necessary to support development of informed management objectives. Similarly, a feedback loop from monitoring is required to assess the success of management actions and progress toward those objectives. A large scale, coordinated and consistent national program would meet those needs at scales that are relevant for bird populations and major land uses. Such a program could also form the foundation for monitoring by many industrial players, avoiding an ad hoc approach of multiple, small, disconnected programs that draw crucial resources. It would enable Canadians to look beyond the resource tenure of individual companies to truly address questions of regional, provincial, and national sustainability.

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