Using Biodiversity Indicators to Assess the Success of Forecasting Adaptive Ecosystem Management: The Newfoundland and Labrador Experience

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Abstract—*This paper reports on an initiative referred to as the Biodiversity Assessment Project (BAP). A suite of tools is being developed to assist forest managers in assessing the predicted future forest conditions of Newfoundland and Labrador's forests under a variety of management scenarios.*

Since 1999, the Western Newfoundland Model Forest partnership has worked with the Institut Québécois d'Aménagement de la Forêt Feuillue (IQAFF) to develop a suite of strategic planning tools that assess the impact of various forest management scenarios on selected biodiversity indicators. This original approach began with Millar Western Forest Products Ltd. (MWFP) in Alberta, Canada, in cooperation with Peter Duinker, Lakehead University, and is now being modified to fit the Newfoundland and Labrador forest condition.

The preliminary results show that forest management actions can have significant impact on various biodiversity indicators, depending on the selected management scenario.

There are several components to BAP. The coarse filter layer examines the ecosystem diversity and landscape structure indices. The fine filter layer focuses on species-specific Habitat Suitability Models (HSMs). WNMF is also defining the natural disturbance regimes for western Newfoundland and comparing the selected biodiversity indicators between a natural forest condition and a managed forest. This future control forest will be used to set the natural range of variation on each biodiversity parameter being used for assessment.

The BAP tools will also be developed to assess central Newfoundland eco-regions so they can be used throughout the province and applied to specific situations, such as fire-dominated ecosystems. The BAP will begin to be incorporated in the provincial wood supply analysis starting in 2005 as a prototype assessment tool.

Introduction

Traditional Forest Management

What is now known as the province of Newfoundland and Labrador is two separate land masses. Newfoundland is often referred to as the island portion of the province and has a total land mass of 11.1 million hectares (ha). Labrador is located northwest of the province of Quebec and has a land mass of 29 million hectares.

Since the turn of the 15th century, the people of Newfoundland have been steadily evolving in the way they interact with the forest around them (Griffin 1979). Griffin used the following headings to define the history of forest management in Newfoundland and Labrador:

1. The period of destruction: 1497 to 1880
2. Exploitation and protection: 1880 to 1934
3. The foundation of an administrative framework: 1934 to 1949
4. The beginning of extensive forestry: 1942 to 1972

The forest of Labrador has seen limited development compared to the island of Newfoundland. Traditional use of the Labrador forest was primarily based on its utilization by Aboriginal peoples, Innu and Inuit, for subsistence living until the 20th century. Even today, sustainable forest management in Labrador is at a much smaller intensity with a harvest allocation of only 30 percent of the annual allowable cut (AAC). Forestry in Labrador is seen as a co-management challenge by the Innu Nation and the Government of Newfoundland and Labrador.

The island is a different story. Coastal regions of the island saw intensive development up until the late 1800s.

Trees were used for building homes and commercial structures, boats, fishing flakes, stages, and for fuelwood. Three miles in from the coastline was considered the "three mile limit" and allowed fisherman to cut the forest within this area (Nazir and Moores 2001) without restriction. Insular forest utilization before then was based on subsistence activities of the Beothuk Indians. European interests turned toward the forest in the mid to late1800s as the sawmill industry began to expand. In the early 1900s, the pulp and paper industry began to be the primary forest-based industry. Beginning on the west coast of the island, the pulp, and paper industry swept across the province, utilizing the most merchantable and accessible stands. For the past 100 years, forest management has evolved from forest protection to timber management to multiple use management, and today, sustainable forest management (SFM) (Newfoundland Forest Service 2003).

Evolution to Sustainable Forest Management

Nazir and Moores suggested that Griffin could add two additional categories to the evolution of forestry in Newfoundland and Labrador to include:

5. Integrated management: 1972 to 1990
6. Sustainable forest management: 1990 to present (Nazir and Moores 2001)

Integrated management required managers to take a larger view of their activities when involved in resource management. Having to integrate all parts of the resource equation to obtain a harmonious whole was the greatest challenge, causing conflicts with inter-governmental policies and responsibilities. After years of striving for accommodation and compromise, managers began to bring issues together and unite under common resource objectives (Mitchell 1986).

With the Canadian Council of Forest Ministers (CCFM) embracing the Criteria and Indicators definition of sustainable forest management (CCFM 1995), forest managers and decision-makers now had to think outside of anthropogenic causes and effects and begin understanding ecological processes outside their realms of expertise. The six criterion for SFM encompass every element of forests, not just the elements that are impacted directly by harvesting, road building, or silviculture. Talking about sustainable forest management is one thing - understanding the complexities of interactions is another. Agreeing to working within a local level indicators framework, an essential component of CCFM's SFM framework, also meant tracking temporal performance indicators and setting thresholds for variability in indicator performance. Newfoundlanders and Labradorians now had to examine the gaps in their resource knowledge base and begin being accountable for their resource management decisions.

The Challenge of the SFM Process

Industry, government, and community organizations had to become more unified to take on the new challenges of resource management. In 1992, the Western Newfoundland Model Forest (WNMF) was formed as part of the national model forest network. Its diverse range of partners set the stage for formulating approaches to SFM in light of limited resources, both financial and knowledge-based. A community-based stakeholder organization has the ability to cut through red tape and leverage resources from a number of agencies and programs. The number one priority of the WNMF has been to develop a framework to help evaluate the effects of long-term forest management activities on forest structure, ecosystem diversity and a select set of wildlife species. This unified approach to address the challenges of SFM has been called the Biodiversity Assessment Project (BAP) (Duinker and others 2000). BAP is the focus of this paper.

Process Inclusiveness

BAP provides an opportunity for those with an academic and management interest in forest connectivity and fragmentation, species utilization of habitat, and natural forest succession to come together as a community to assist managers in resolving the ecological challenges confronting them. Striving to achieve SFM requires forecasting and monitoring the effects of present day and future management activities on suites of indicators. The approach BAP adopted was to use local level indicators of biodiversity that could be both used in monitoring and in forecasting ecological impacts.

In defining SFM, Criteria and Indicators (CIs) are divided into two separate components. Ecological CIs are illustrated under the following titles:

1. Conservation of Biological Diversity
2. Maintenance and Enhancement of Forest Ecosystem Condition and Productivity
3. Conservation of Soil and Water
4. Forest Ecosystem Contributions to Global Ecological Cycles

Socio-economic CIs focus on the last two titles:

5. Multiple Benefits to Society;
6. Accepting Society's Responsibility for Sustainable Development (CCFM, 1995)

BAP concentrates on the first and second criterions of SFM. WNMF is working on integrating several other

complementary approaches with BAP to address the remaining criteria.

The complex, multi-faceted nature of biodiversity brings about the need to better address our limited knowledge of resource processes and their associated bio-indicators. BAP must be flexible and adaptive in order to integrate what we do know about ecological processes with what we need to find out.

MWFP of Alberta, first approached a team of scientists to create a system that anticipates the complexities of forest systems at a landscape scale. BAP-Alberta was a multi-million dollar project with 29 specific habitat suitability models. According to Starfield and Bleloch (1986), models are tools which "help us to (1) define our problems, (2) organize our thoughts, (3) understand our data, (4) communicate and test that understanding, and (5) make predictions." Therefore, models are learning tools that can help determine the impacts of any external perturbation on the entire system (Higgelke 1994). WNMF partners liked the way MWFP approached the complexities of biodiversity assessment and brought that process to western Newfoundland but WNMF had a different perspective on the implementation of this project. The WNMF partnership includes a multitude of various agencies and organizations, existing resource databases, and facilities to broaden the ownership of such an initiative. In the long term, BAP will assist WNMF in integrating information on forest parameters under the ecological CIs, but with limited resources, WNMF project managers decided to start small with the implementation of BAP. WNMF partners applied adaptive ecosystem management principles in order to progress in the development of BAP.

"The adaptive process maximizes the manager's learning about the system, and is consequently a safe approach to initiating management in complex systems" (Baskerville 1985). In designing forest management goals and associated actions, the measurement of progress is carried out in a manner that allows the manager to learn about the complex system from his/her management of it. The BAP allows one to forecast management actions in a well-defined feedback loop, as illustrated in figure 1, and track the resulting effects for a variety of management actions. BAP users are forced to recognize errors in their proposed assumptions, thus allowing for continuous learning from system performance.

Ecologists, biologists, foresters, research scientist from numerous disciplines, and resource managers all have a role to play in integrating their knowledge and developing assumptions on ecosystem structure and function when knowledge gaps are confronted. The outputs of their efforts will be integrated into a common framework to assess impacts of forest management activities.

Partnerships

The WNMF partnership is comprised of federal, provincial, and municipal government agencies, industry organizations, economic development associations, environmental organizations, academic institutions, and a commercial trapping group. The partnership wanted the BAP to be a tool utilized by all sectors of resource management, not just industry. The partnership was the catalyst for transferring BAP to WNMF and put together a team of resource planners, managers, ecologists, biologists, and computer specialists from a multitude of different organizations. They formed the Biodiversity Assessment Project Working Group (BAPWG), which is directed by the following partners:

Industry

- Corner Brook Pulp and Paper Limited - Chair of BAPWG
- Abitibi Consolidated Company of Canada

Federal Government

- Natural Resources Canada, Canadian Forest Service
- Parks Canada, Gros Morne National Park

Provincial Government

- College of the North Atlantic, Geospatial Research Facility (GRF)
- Department of Environment and Conservation, Inland Fish and Wildlife Division (IFWD)
- Department of Environment and Conservation, Water Resources Division
- Department of Natural Resources, Forestry Services Branch (FRB)

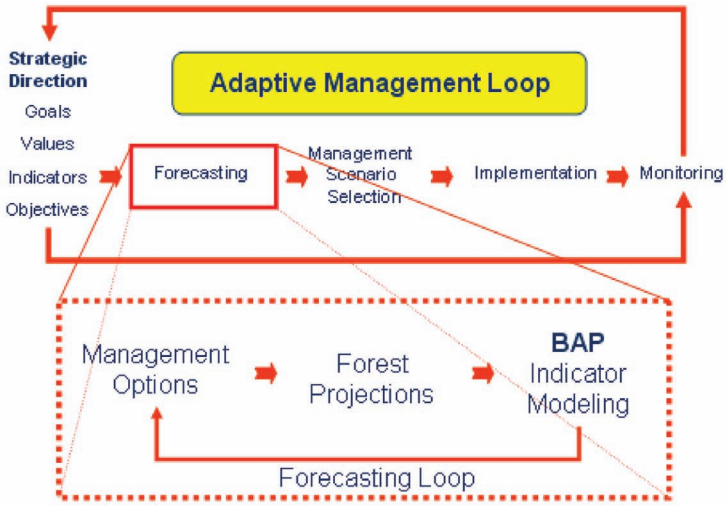

Figure 1. Adaptive Management Loop (Doyon 1999).

Community

- Western Newfoundland Model Forest

Working on behalf of the BAPWG is a technical subcommittee guided by the original researchers involved with MWFP. It is the objective of all partners to cooperatively transfer BAP-Alberta models to the WNMF. WNMF is developing and testing BAP tools in order to accurately predict our future forest conditions under both natural and human influences.

Public Participation

Accountability is the cornerstone of the WNMF partnership and the BAP. Public participation and input into forest management has two direct avenues. Public associations and individuals have direct access to WNMF resources and will be provided access to working groups unless they will not agree to the ground rules of consensus decision-making. BAPWG has an open chair policy for organizations wanting to participate in the development process of a specific initiative.

The second avenue addresses the implementation stage of the BAP. The Forestry Services Branch of the Provincial government's Department of Natural Resources manages the forests of this province. It is responsible for ensuring that forest management districts prepare management plans in consultation with public and community stakeholders. Local planning teams prepare strategic documents and five-year operating plans that incorporate both timber and non-timber forest values. One of the major areas of concern for these planning teams is the ability to forecast the impacts of their future management directives. Are they truly practicing SFM in their districts? What are the ramifications of different management scenarios on biodiversity? BAP will be their future tool to ensure some level of confidence in their decision-making abilities.

Capacity Building

The future application of BAP is dependent on the relationship established between the inventory agencies, research community, forest resource managers, and the planning teams. The desired outcome of forest management decisions has to be a result of trade-offs between user groups and the natural variability of biophysical indicators. BAP, when used in a negotiating process, will provide a number of scenarios to participants, thus building their capacity to assess the biodiversity outcomes of these virtual scenarios.

BAP Process Overview

BAPWG is presently running analyses on four different scenarios using the output of the wood supply projection models - Woodstock and Stanley (Remsoft) of the Forestry Services Branch. The four scenarios are:

1. Business as usual – if management was to stay as presently practiced with the current annual allowable cut.
2. Business as usual: Fragmented – if the average five year harvest block was to stay at 50 ha in size with a variability between 10 and 100 ha. A green-up delay of 5 years would be imposed for harvesting adjacent blocks.
3. Business as usual: Aggregated - if the average five year harvest block was to stay at 300 ha in size with a variability between 100 and 800 ha. There would be no green-up delay for harvesting adjacent blocks.
4. Marten Friendly – This scenario respects the landscape thresholds set by the Recovery Team for Newfoundland marten. There will be no mean block size but a minimum of 10 ha and no maximum limit. Tree height would have to be maintained at greater than 6.5m with no green-up delay.

Also being run concurrently is a landscape simulator that incorporates the natural disturbance regime of the WNMF study area, Forest Management District 15. Through a series of applied research projects on insect disturbed forest areas, Dr. Yves Jardon of the Institut Québécois d'Aménagement de la Forêt Feuillue (IQAFF) produced historical outbreak data that he used with LANDIS. LANDIS is a commercial landscape simulator model capable of producing a future forest scenario void of anthropogenic disturbances and based on projecting only natural forest succession processes. This natural disturbance regime scenario, when analyzed by the BAP tools, gauges the natural range of variability of the bio-physical indicators, setting minimum and maximum thresholds.

BAP has three levels at which these scenarios will be assessed:

1. ecosystem
2. landscape
3. species specific

Coarse-Filter Biodiversity Analyses

At a coarse level of bio-indicators, ecosystem diversity and landscape configuration are targeted (Doyon and MacLeod 2000). The following set of bio-indicators is thought to broadly consider the basic habitat requirements of forest-dwelling, vertebrate species (Rudy 2000).

Ecosystem diversity

Bio-indicators used in the analysis of ecosystem diversity are:

- Area-weighted Stand Age
- Tree Species Distribution
  - Species distribution by broad habitat type
  - Species presence
  - Species dominance
- Habitat Diversity

These three indicators enable BAP to track the changes in forest composition due to management practices being projected.

Landscape configuration

Bio-indicators used in the analysis of landscape configuration are chosen for their sensitivity for gauging the impact on connectivity. These bioindicators are:

- Average patch size and shape
- Average edge contrast/Edge length
- Patch core area
- Adjacency
- Nearest neighbour

Fine-Filter Biodiversity Analyses

At a fine-filter level of assessment, habitat supply models were developed for specific wildlife species. As of August 2004, the BAPWG has models for Newfoundland pine marten (Martes americana atrata), woodland caribou (Rangifer tarandus), and boreal owl (Aegolius funereus). All models follow the same format and utilize harvest projection inventory tables produced by each scenario.

Species specific

In a forest management context, some wildlife species, because of their individual characteristics, need to be analyzed separately (Doyon 1999) and cannot be generalized into core wildlife groups. A species status as an indicator or keystone species may determine their priority for modeling in BAP.

The BAP uses specific species to analyze the forest in terms of future habitat potential for that wildlife species. BAPWG has chosen an initial suite of species based primarily on data availability but also because of their diverse habitat requirements. In 2004 to 2005, the Inland Fish and Wildlife Division of the Provincial government's Department of Environment and Conservation, as the biological experts on the BAPWG, will choose a suite of future species by evaluating several forest species according to the criteria listed in table 1.

BAP Flow

The following process diagram (fig. 2) illustrates how BAP fits into interdisciplinary research and decision making in Newfoundland and Labrador. The BAPWG is responsible for the transfer and development of BAP tools. Once the prototype has been developed and accepted, the partners of the BAPWG will be responsible for further refinements and implementation. As figure 2 illustrates, BAP is dependent on many sources of input. Once the forest inventory specialists have provided the basis for the projections in the province's wood supply projection models, Woodstock and Stanley, and researchers have provided further information on other ecosystem components, BAP can generate a stand attributes table for assessment. The assessment is filtered through the coarse stream for ecosystem and landscape analyses once the habitat reclassification is done. Concurrently, the bio-indicators will be filtered through the fine stream where the habitat requirements to select which species will be assessed.

Decision Making

BAP is designed as a decision support system for both the public consultation process and the provincial wood

Table 1. Criteria for Selecting BAP Species (Doyon 1999).

Criterion	Description
Sensitivity to Disturbance	Expected to be sensitive to intensive forestry practices
Species status	Have been given rare, vulnerable, threatened, or endangered status
Monitoring	Easily monitored (relatively common with entire home range contained within the FMA area)
Habitat specificity	Have specific requirements for particular habitat types
Special habitat elements	Use special habitat elements such as snags, downed woody debris, and arboreal lichens
Functionally essential species	Have substantial influence on the ecosystem (top predators or large browsers)
Landscape configuration	Expected to be sensitive to landscape composition and structure (area- or edge-sensitive species)
Socio-economic value	Hunted, trapped, viewed, or photographed by local people
Available information	Have been studied extensively

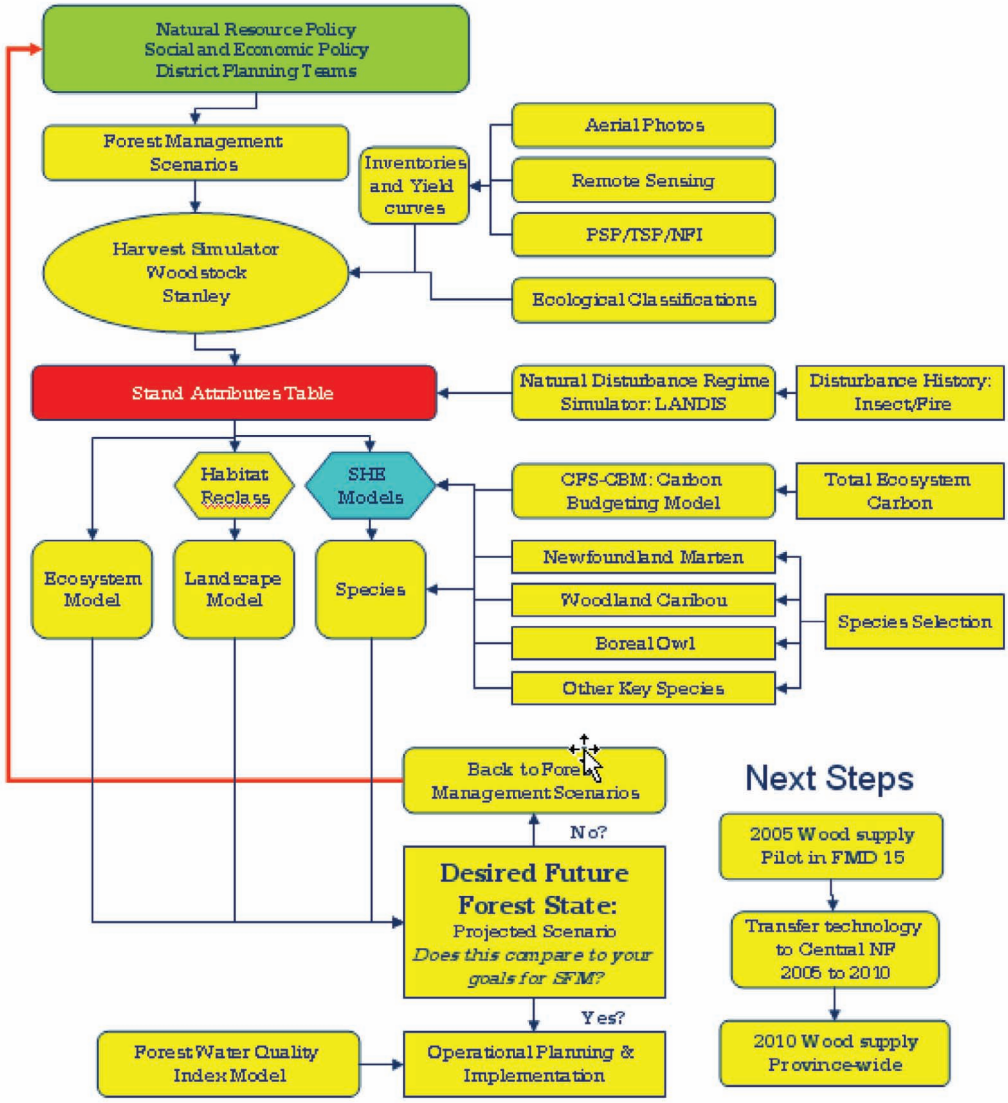

Figure 2. BAP Process.

supply analysis. Once integrated into the provincial forest management planning process, each district planning team will be responsible for setting the constraints for different management scenarios. After the bio-indicators for each management strategy are analyzed, compared, and evaluated, the planners and planning teams will receive an opportunity to decide if the outcome of the projection compares with their goals for SFM. If they do not, re-testing of management scenarios occurs until an acceptable management strategy is achieved (Newfoundland Forest Service 2003).

Conclusion

The Western Newfoundland Model Forest is committed to seeing the BAP process through to its adoption as a formal mechanism for protecting the biodiversity of Newfoundland and Labrador forests. As a partnership, we do have concerns over the balance of ecological integrity, economic sustainability, and social rights and freedoms when developing decision support systems for forest management. Process transparency, access to information, and providing the opportunity for community participation will ensure the success of the Biodiversity Assessment Project and its incorporation into the public consultation process for decisions on forest management planning in Newfoundland and Labrador.

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