Implementation of a Monitoring Pilot Study for Ontario Parks in Ecoregion 5E

Jennie Aikman, Tim Bellhouse and Rob Davis
Ontario Parks

Abstract

As part of Ontario's Living Legacy (OLL), Ontario Parks has undertaken a pilot project to report on the state of Ontario's system of protected areas in Ecoregion 5E. As part of this pilot, we have collected and compiled data into a Geographic Information System (GIS) database for use in analyzing terrestrial and aquatic indicators at the landscape level. Assembled data sources are analyzed spatially to identify gaps in provincial monitoring networks. Protected areas are seen as distinct areas on the landscape and are often not considered in provincial monitoring programs. Landscape metrics, used to quantify the structure and composition of forested landscapes in protected areas, are identified as a useful suite of indicators. These metrics, employed in Forest Management Planning, provide measures of forest structure and composition. Analysis of landscape metrics for protected areas and intervening lands facilitates comparisons between these two landscapes. Sources of information for reporting and monitoring on the aquatic health of protected areas are also identified.

Introduction

Ontario Parks has undertaken a comprehensive monitoring program to assess the health and sustainability of protected areas in Ontario (for the purpose of this paper the term protected areas refers to Provincial Parks and Conservation Reserves). This monitoring program provides the basis for state of the protected areas reporting. A pilot study has been undertaken in the Georgian Bay Ecoregion (Ecoregion 5E) in order to scope the resources required for monitoring and reporting across the province and to test and refine the implementation of a draft framework for monitoring (North-South Environmental Inc., 2001). Ontario Parks' monitoring framework is designed around three principal components, whose interactions shape ecological sustainability: ecological system, social system and economic system. The 5E pilot study includes all three of these components. This paper addresses the ecological system.

In Ontario Parks' monitoring framework, the ecological component is divided into three inter-related subcomponents: terrestrial, aquatic and atmospheric. This paper addresses the data sources and analysis techniques used as part of the pilot project for reporting on the terrestrial health of protected areas. Data and information gaps in Ontario's existing aquatic and terrestrial monitoring networks are also discussed.

Terrestrial Data Sources and Analysis

Terrestrial Data Sources

The first stage of the pilot project required researching and compiling data from a diversity of sources. Numerous monitoring and inventory programs have been established by different federal, provincial and local agencies within the province. Data from existing monitoring programs, including monitoring site location information, was collected and compiled into a functional Geographic Information System (GIS) and database system. Linking existing monitoring sites to a GIS facilitated the assessment of physical gaps in monitoring networks, particularly as these gaps relate to protected areas. This analysis demonstrated a revealing picture: while numerous programs are collecting important monitoring information on the landscape, minimal monitoring is conducted in protected areas, particularly in long-established parks. With the exception of Algonquin Provincial Park and some newer Ontario Living Legacy (OLL) protected areas, many protected areas have few, if any, monitoring sites within their boundaries.

Data sources collected for the 5E pilot include forest health information (fires, insect and disease, health, growth and yield), wildlife, including bird survey data, Ecological Land Classification data, Forest Resource Inventory data, landcover, geology and soils data. Table 1 provides a partial list of ongoing monitoring programs in Ecoregion 5E and indicates the number of these sites located in protected areas.

Table 1. *List of compiled terrestrial data sources indicating the number of sites in protected areas in Ecoregion 5E.*

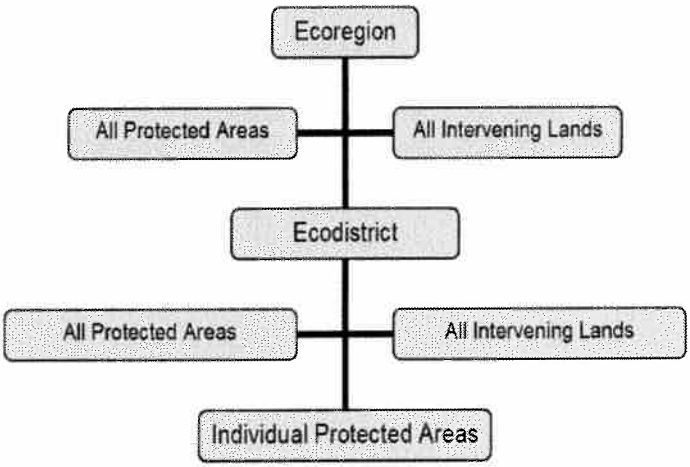
Monitoring Program	Number of Plots in Protected Areas	Number of Plots in Ecoregion 5E
Growth and Yield Plots	27	207
Ecological Land Classification Plots	360	1,215
Wildlife Assessment Program Plots	0	76
Ecological Monitoring and Assessment Network (EMAN)	1	3
Forest Health Plots	28	162
Forest Bird Monitoring	44	97
Marsh Bird Monitoring	3	35
Nocturnal Owl Survey	6	78
Red Shouldered Hawk Survey	2	58

Terrestrial Landscape Analysis

Ontario Parks has adopted a hierarchical approach to monitoring, based on Ecological Land Classification (ELC) (Bellhouse, 2002). The ELC system acknowledges that biological organisation occurs across a range of nested scales at which the structure, composition and function of ecosystem elements interact. At the broadest scale of biological organisation, assemblages of ecosystems interact within a landscape (North-South

Environmental Inc., 2001). This section addresses the analysis of terrestrial ecosystems at the broadest, landscape level. For the purpose of the 5E pilot, the landscapes considered include the ecoregion, nested ecodistricts and individual parks and conservation reserves. At the ecoregional and ecodistrict levels of analysis, landscape metrics are calculated separately for both protected areas and the intervening lands between protected areas (Figure 1). This type of analysis facilitates comparisons between protected areas and intervening landscapes.

Figure 1. *Landscape-scale reporting units for terrestrial sub-component.*



Landscape metrics are used as indicators of forest health, providing quantitative measures of ecosystem structure and composition which can be measured and tracked over time. Landscape metrics evolved from the notion that patterning of landscape elements, called patches, has a strong influence on ecological characteristics. Understanding ecosystem structure using metrics is a necessary prerequisite to understanding landscape function and assessing change (McGarigal and Marks, 1994).

In Ontario, the Forest Management Planning process requires forest managers to report on the six indices of landscape structure and composition. These six indices include composition and diversity, edge, interior, fragmentation, isolation and spatial pattern (Ontario Ministry of Natural Resources, 2002). Each of these indices has a number of metrics that can be calculated using a GIS and modelling tools, to yield information about the landscape as whole and individual classes of ecosystems nested within the landscape being studied.

Forest Resource Inventory

Ontario's Forest Resource Inventory (FRI) database was used as the data source for classifying the landscape into forested and non-forested ecosystem groupings for landscape analysis. FRI has the most detailed land cover information available for Ecoregion 5E, and consists of polygons mapped from interpreted aerial photography at a scale of 1:10,000 in southern Ontario and 1:20,000 in northern Ontario. One limitation of the dig-

ital FRI database is that it does not cover the entire province of Ontario, being restricted to the area of active forest management. There is no FRI data available for protected areas above the 51st parallel and only outdated, hardcopy mapping in southern Ontario. In these areas, satellite-based landcover data, including Ontario's Landsat-derived landcover dataset, and Southern Ontario Land and Resource Information System (SOLRIS), when available, will be required.

Land Cover Classification Schemes

The classifications and metrics used in the 5E pilot were adopted from those used by the Forest Management Planning units in Ontario. Individual forest stands in the FRI are grouped into four classifications based on ecosite type (Chambers *et al.,* 1997), forest development stage (pre-sapling, sapling, immature, mature and late-successional) and species associations based on ecosite classifications (red and white pine, jack pine and black spruce, intolerant mixedwood, tolerant hardwood, lowland conifer mixedwood). Figure 2 illustrates the grouping of forest stands into these four classification schemes. In addition to the forest classifications, the landscape was also grouped into broader landcover classes including: forest and disturbed forest, woody shrub habitat, wetlands, lakes and rivers, agricultural lands and fields, bedrock, corridors and developed and unclassified lands.

The first classification scheme grouped the 25 ecosite types found in Ecoregion 5E by five forest development stages (see above). While this classification yields a cumbersome number of groupings (125 classes), it is important for observing the change in the abundance of less common forest types. Analysis of this classification yields useful information about landscape composition and diversity. For the second classification scheme, five species associations (see above) were grouped by three development stages (pre-sapling, sapling and immature, mature and late-successional). This classification captures critical variation in habitat for terrestrial invertebrates. The third classification scheme is useful for examining patterns of landscape disturbance. Here, forested polygons were grouped into disturbed and undisturbed patches, based on age classifications. All pre-sapling and sapling patches were classified as disturbed. The fourth classification is useful for characterizing the landscape into young and old forest patches, based on development stages. This classification is used to analyse the level of fragmentation of undisturbed and mature forest.

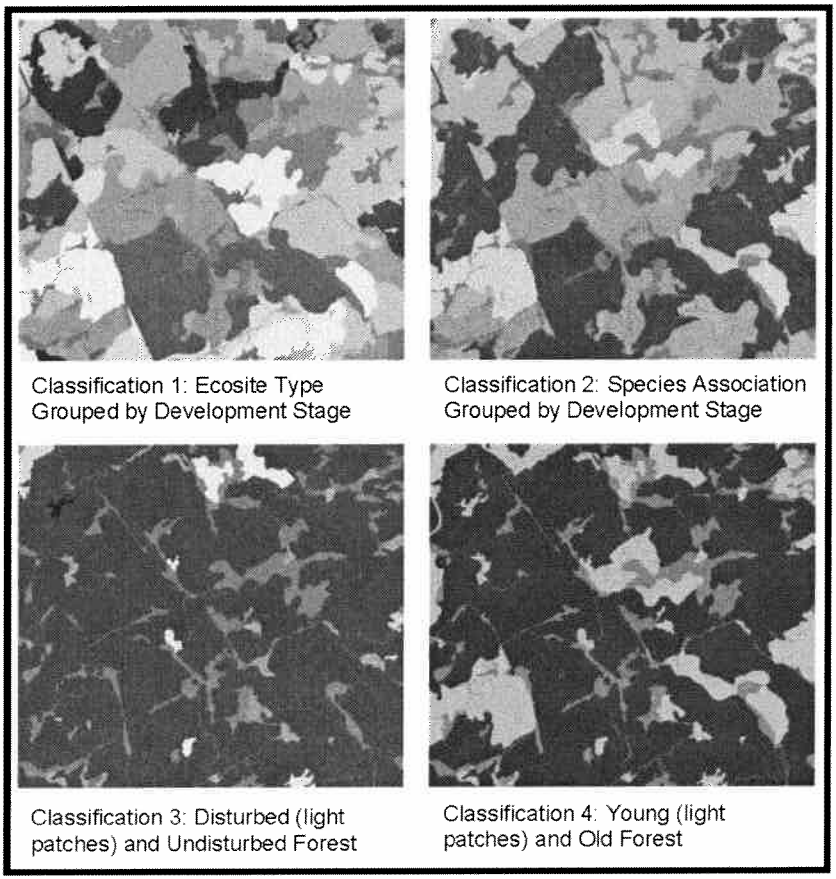
Landscape Indicators – Metrics and Measures

As mentioned above, there are metrics which yield information for each landscape indicator. Composition refers to the amount and proportion of area of each class and diversity comprises richness and evenness. Analysis of composition and diversity are applied to all four classification schemes. Metrics such as the percentage of the landscape, class area and total class richness are calculated for each class. Both forested and non-forested features were examined. Composition and diversity metrics provide benchmark information for each protected area and will enable monitoring of changes in landscape composition over time.

Measures of edge are also analyzed. Here, boundaries between different forest patches represent a change in environmental conditions, and affect the movement of biota across

the landscape. Edge metrics include measures of edge density (total length of edge per ha) and analysis of the area of different landcover classes along the protected area perimeter. Changes over time in the amount and type of edge yield important information on external stresses on protected areas.

Figure 2. *Illustration of forested patches grouped into the four classification schemes used for landscape analysis.*

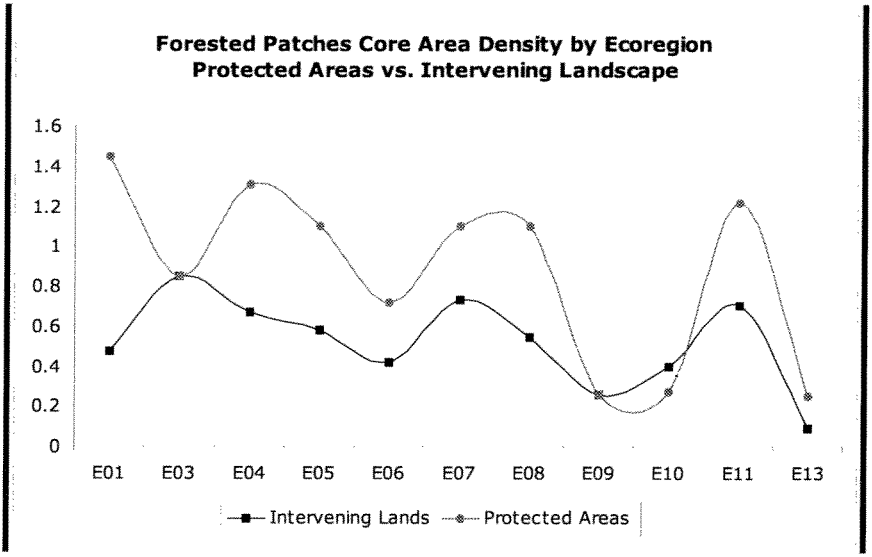


Core habitat represents the amount of area of a patch that is not influenced by surrounding patches. Core areas are regions of habitat that are greater that 200 m from a patch edge. Studies have shown that important edge influences from microclimate, pioneering plants and nest parasitism can occur within 200 m of an edge in mature forest (Bellhouse, 2002).

Loss of core areas could result in the decline in species, including interior forest dependent species such as the pileated woodpecker and pine marten, which are dependent on core habitat. Monitoring total core area, mean core area and core area densities (Figure 3) are useful for determining the amount and size of core habitat in the landscape.

Fragmentation, a term well recognized in the field of landscape ecology, can be measured in many ways. This project examines fragmentation by looking at the mean patch size (in hectares) of broad landscape units and development stages, using the second classification scheme (see above) and the relative frequency of patch sizes based on Ontario's Natural Disturbance Emulation Guidelines (Ontario Ministry of Natural Resources, 2003). The density of roads and corridors are also calculated, as are the percent of roadless areas.

Figure 3. Comparison of density of core areas (number per 100 ha) for protected areas and intervening lands.



Isolation refers to the distance between patches of similar composition and is important for species interactions and dispersal. Mean nearest neighbor metric is used to measure the distance between similar patch types. Forest spatial pattern is further revealed by the interspersion and juxtaposition index, which quantifies landscape configuration by measuring the extent to which patch types are interspersed across the landscape.

Old Growth

Old growth classifications were determined based on the Old Growth Forest Definitions of Ontario (Ontario Ministry of Natural Resources, 2003). The age of onset of old growth varies based on ecosite type from 90 years, in hardwood dominated mixedwoods, to 160 years for some tolerant hardwood stands. The percentage of area classified as old growth was reported for both protected areas and the intervening landscape (Figure 4).

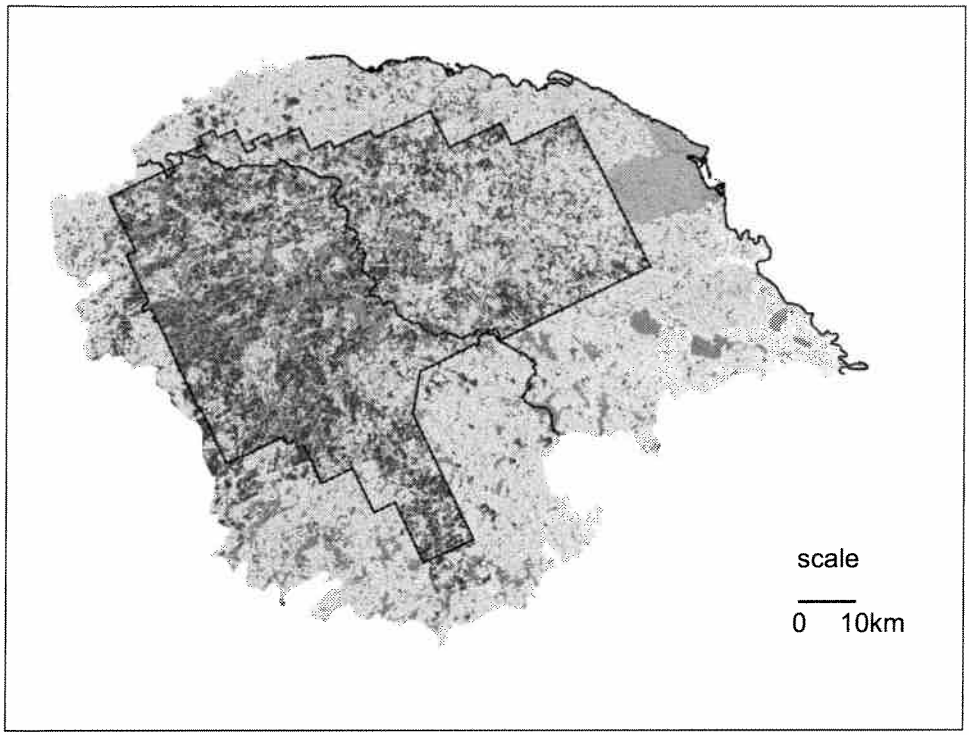
Aquatic Data Sources and Analysis

Aquatic Data Sources

While the value of aquatic features and ecosystems is well recognized by Ontario Parks,

the focus of protected areas management has been on terrestrial ecosystems. With the development of a comprehensive monitoring project, it is essential that aquatic ecosystems be measured as part of an assessment of ecological integrity. As part of the 5E pilot monitoring project, aquatic data sources from numerous agencies were compiled (Table 2).

Figure 4. *Map of old growth forest patches (darkest patches) found in Algonquin Provincial Park and surrounding Ecodistricts, 5E-9 and 5E-10.*



Data collected includes information on fisheries (surveys, stocking lists, fish contaminant sampling, spawning and feeding areas), water quality (Ontario Parks water quality database, Provincial Water Quality Monitoring Network, Lake Partners Program, benthic biomonitoring, Long Range Transport of Air Pollutants (LRTAP) Biomonitoring), water flow (HYDAT), stream and lake surveys, dams and evaluated wetlands. Compiling all the sources into a GIS database revealed that although there are numerous aquatic inventories and monitoring networks within the province, protected areas are inadequately represented. Two provincial parks depart from this picture -Killarney and Algonquin. Research into aquatic ecosystem monitoring is taking place in Killarney Provincial Park in partnership with Environment Canada's Ecological Monitoring and Assessment Network (EMAN). There are numerous aquatic research and monitoring projects in Algonquin Provincial Park, including the Harkness Laboratory of Fisheries Research and Canadian Wildlife Service's Long-Range Transport of Air Pollutants (LRTAP) Biomonitoring Program lake sites.

Table 2. List of compiled aquatic data sources indicating the number of sites in protected areas in Ecoregion 5E.

Monitoring Program	Number of Plots in Protected Areas	Number of Plots in Ecoregion 5E
Provincial Water Quality Monitoring Network (MOE)	1	30
Lake Partners Program (MOE)	47	266
Sportfish Contaminant Sampling Sites (MOE)	48	474
Waterflow Monitoring Netwo rk (MOE, MNR, CAs)	3	76
Benthic Biomonitoring Network (MOE)		
Lakes	6	277
Streams	21	100
Stream Inventory (MNR)	To be determined	To be determined
Lake Inventory (MNR)	494	3,077
Fish Stocking (Destination Waterbodies) (MNR)	44	161
LRTAP Biomonitoring (CW S)	12	56
Fire Weather Stations (MNR)	22,724	197,778
Snow Monitoring Network (MNR)	2	59

Aquatic Analysis

Aquatic data is being analyzed primarily on a tertiary watershed basis, which is consistent with the reporting level for many provincial aquatic monitoring programs. Where possible, aquatic information will be reported on a park-by-park basis and/or by quaternary watershed. Linking the protected areas to their surrounding watersheds enables the assessment of upstream and downstream water quality and the effects of structures such as dams and road crossings. Reporting for some aquatic indicators will be rolled-up to the ecodistrict level to identify linkages between terrestrial and aquatic systems.

Data Processing

Data processing and analysis steps were fully automated in a GIS, facilitating the replication of analysis, as new datasets become available. The results from this analysis have been incorporated into a relational database to simplify and standardize reporting formats for state of the protected areas reporting.

Summary

As part of the Ecoregion 5E pilot project, terrestrial and aquatic monitoring and inventory data sources have been collected and compiled. Although there is a wealth of informa-

tion on terrestrial and aquatic ecosystems within the province, examining this information spatially reveals gaps in provincial monitoring networks in protected areas. Protected areas need to be further integrated into existing monitoring and inventory initiatives. Ontario Parks must continue to develop partnerships with agencies involved in monitoring within the province. Protected areas represent a valuable resource to many monitoring programs, as fundamentally undisturbed reference sites, providing benchmark conditions against which other sites in the managed landscape can be assessed.

Our landscape-level analysis of terrestrial ecosystems includes the calculation of forest landscape metrics to examine the composition and structure of the forests in protected areas. All analysis has been done on both protected areas and intervening landscape, to reveal differences between the structure of managed and unmanaged ecosystems. Landcover, old growth and patterns of disturbance have also been analyzed. The results of this analysis have been built into a relational database to facilitate analysis and produce reports for State of the Protected Areas reporting.

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