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EMAN: MONITORING BIODIVERSITY IN CANADIAN FOREST

EMAN RESE

Ecological Monitoring and Assessment Network
Le réseau d'évaluation et de surveillance écologiques

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The EMAN forest biodiversity monitoring is a work in progress; this publication is an attempt to unite participants and focus the network towards the common goal of monitoring ecological change, over the long-term, at a national level. The network, and therefore this publication, would not exist without the encouragement and participation of all those involved in long-term ecological monitoring. We would like to name some of the individuals whose hard work made this publication possible.

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EXECUTIVE SUMMARY

Ecological Monitoring is used for the observation and evaluation of organisms, populations and/or communities to detect changes in ecological systems through time.

The study of biological diversity is essential in order to increase our understanding of our natural environment and increase our awareness of changes within that environment. Ecological monitoring is a tool that can be used to collect data on trends related to biological diversity. The data collected through monitoring programmes can reveal early indicators of ecosystem problems, allowing for investigation into the sources of ecological changes and possible abatement of adverse effects. Monitoring allows us to recognize shifting in our natural areas. This information can help us to better understand our resource use and environmental impacts by helping to direct further study into the status and trends found through the interpretation of ecological monitoring.

Monitoring programmes help meet goals set out by the Canadian Biodiversity Strategy, Canada's formal response to the United Nations Convention on Biological Diversity. The strategy outlines objectives for Canada to meet in order to protect biodiversity. One of these goals is the improvement of ecosystem understanding. The Ecological Monitoring and Assessment Network (EMAN) can meet this goal through the development of standardized protocols for monitoring changes in biodiversity and through outreach programmes which encourage members of the community to participate in voluntary data collection and to commit time and resources to monitoring projects.

EMAN Ecosystem Monitoring Protocols

During the last seven years, EMAN partners have established over ninety monitoring plots using the Smithsonian Institute / Man and Biosphere (SI/MAB) biodiversity monitoring protocol which was originally developed for tropical forest ecosystems. Dr. Patricia Roberts-Pichette and Dr. Lynn Gillespie, in cooperation with the Biodiversity Science Board of Canada, subsequently adapted this protocol (with the assistance of the Smithsonian Institute) and added other methods for a more integrated approach to plot-based ecosystem monitoring in Canada. The EMAN Terrestrial Vegetation Monitoring Protocols set out how to undertake inventories for long-term vegetation monitoring. These protocols are recommended for use in new long-term monitoring projects or as additions to current monitoring work. EMAN protocols are not recommended as replacements for ongoing projects.

The Terrestrial Vegetation Monitoring Protocols are to be used in the collection of data on plant species for a plot-based monitoring inventory. The EMAN Coordinating Office (EMAN CO) is developing a set of standardized ecosystem monitoring protocols (EMP) to monitor a variety of indicators, which will work together as a suite to detect and track ecosystem changes over time. These abiotic, biotic and cultural ecosystem indicators can be implemented in conjunction with the Terrestrial Vegetation Monitoring Protocols to provide the basis for a sound comprehensive forest biodiversity monitoring programme.

The protocols are standard methods for measurement of indicators that are laid out in detail for a variety of users. When used properly, standardized methods of data collection allow for information collected by different users to be compared. This comparison through data integration or manipulations can provide for understanding of ecological changes at different scales within an ecozone or ecosystem type or can be used to provide ecosystem information at a local, regional or national level. The protocols, though created in conjunction with ecological experts and specialists, are presented in a way that allows for them to be understood by community partners with differing levels of scientific background. Understanding of these protocols is necessary so that data can be collected accurately. These protocols were created for a wide audience and can be implemented by protected area managers, landowners, researchers, educators, post-secondary students and other members of the community interested in long-term ecological management and monitoring.

Protocols and data collection are only part of the monitoring process. Once measurements are made and

information is gathered, data should be analysed and results put into a usable form in order to understand changes in ecological systems. Therefore, it is important to stress the need for data archiving. Long-term monitoring programmes depend on proper storage of results and samples (such as voucher species) that will allow for comparisons with future findings or other monitored sites. Data archiving is perhaps the most essential part of any successful long-term monitoring programme, though it is often overlooked. After inventorying, it is important that data and samples are stored quickly and in a manner that can allow for it all to be understood in the future or by other researchers. The BioMon programme has been developed to store and summarize large amounts of vegetation information and is the recommended programme for the storage of data obtained from the EMAN forest monitoring plots. Instructions for storing voucher plant species are available on the EMAN website.

Over the last seven years, EMAN and its partners have been building a network of information on monitoring sites, monitoring projects and monitoring protocols in Canada. The goal of this network is to have a monitoring and assessment system that provides information on the status of Canadian forests and is able to give direction for the future of ecological monitoring.

Several issues relating to the growth and improvement of the EMAN monitoring network should be addressed. These include the establishment of new plots, the addition of new protocols, the re-inventory of current plots, information management systems, feedback and assessment and finally partnerships.

This publication addresses the unique role that the EMAN forest monitoring plots have in attaining the goals outlined first, in the Canadian Biodiversity Strategy and second, in helping EMAN to coordinate, standardize and link efforts undertaken across the country to inventory and monitor biodiversity change in forest ecosystems. Because of the simplicity of the data collection, the size of the plots, the thoroughness of the vegetation inventories and the utilization of numerous, complementary monitoring protocols, the EMAN forest biodiversity plots fill a unique niche in allowing us to assess what is changing and why in terms of forest biodiversity.

Ultimately, the purpose of this publication is two-fold:

1. to encourage the expansion of biodiversity monitoring in Canada - to show how the original SI/MAB concept has evolved and expanded in Canada to incorporate biodiversity monitoring of forested and non-forested systems as a whole and;
2. to provide a forum for participants to share information and data, their successes and challenges and to acknowledge their contributions in building an effective Canadian biodiversity monitoring programme.

As a result, the target audience for this publication is fairly broad as it is written for University Research Stations to Community Groups.

Future Directions

> *"The Ecological Monitoring and Assessment Network is composed of partners who work collaboratively to improve the effectiveness of ecosystem monitoring and to demonstrate its relevance by better informing decision-making and influencing behaviours."*
>
> Dr. Hague H. Vaughan, Director of EMAN Coordinating Office

The adoption of a national comprehensive plot-based biodiversity monitoring programme coincides with the overall mandate of EMAN. The forest monitoring plots are an important part of the future of EMAN and environmental awareness in Canada.

With the establishment of a nation-wide monitoring programme EMAN can then focus on the changes found throughout the country. Using the data from the forest monitoring plots EMAN will be able to influence decision making, direct research and introduce priority issues at a national level.

Through the evaluation of the current forest monitoring plot system, several issues have arisen. The overall goal of a comprehensive nation-wide monitoring programme requires more work in certain areas. The following list outlines the issues, which must be addressed in order to ensure a functional network at national, provincial, regional and local scales.

1. Establishment of New Plots

By looking at our present plot system, gaps in ecological information can be identified. There are several ecozones that have no established long-term monitoring plots or that need more plots in order to provide a representative example of biodiversity status. There are also several forest types that need representation. For example, Karsh (see Analysing and Applying Collected Data section) states that due to the high number of plots in sugar maple stands, other forest types should be given priority when establishing new sites. Plots can also be set up to answer specific research questions about changes in vegetation or changes to specific types of vegetation. According to MacIver (see Case Studies section), in order to detect changes there is a need for plots or transects across different gradients (ecological, chemical and climatic) in landscapes altered by human impacts. Monitoring edge environments can also increase ecological information. New plots can be paired with previously established plots in order to allow for comparison between altered and unaltered environments. Useful information can be gathered from urban sites or stressed areas. The network should also encourage the use of two different plot sizes (20x20m and 1 ha) in a series of locations. Establishing new plots will be encouraged in order to meet the information needs of managers, researchers, communities and government agencies.

2. New Ecosystem Monitoring Protocols

In order to make the information collected from the plots more timely and informative, EMAN needs to expand the type of information collected, to move beyond trees to include other levels of vegetation, other species and other indicators of ecosystem change. Chapter 3 describes the protocols that are developed or under development which are easily implemented as part of a comprehensive monitoring programme. Karsh (see Case Studies section) has also suggested bioregional mapping as a way of understanding the anthropocentric value of an area being monitored. There are also several land types that have not currently been involved in the EMAN monitoring programme. Protocols for plot design and data collection need to be created, adapted to, or standardized for marine systems, freshwater systems, wetlands, prairies, tundra, cropland and urban areas. New protocols and protocol adaptations will continue to be added to the monitoring network in order to maximize the information on ecosystem status and ecological change in Canada.

3. Re-inventory.

In order to track change over time, a re-inventory of plots should be done on a continual basis. Currently only a few sites have been able to re-inventory (Kejimkujik, Mont St. Hilaire and Long Point), and the information that has been gained from the re-inventory process has been invaluable. Re-inventory allows the documentation of changes since the first inventory and notation of emerging issues. EMAN encourages the re-inventory of plots on a timely basis according to an agreed schedule relating to what is being measured, in order to track changes in organisms, communities and/or environmental indicators through time. If we are to use the plots to determine what is changing and why, particularly over the long-term, regular inventories are absolutely essential.

4. Information Management System

Large amounts of data have been and will be gathered on vegetation and this data needs to be put into a useable format. There is a need for a comprehensive information management system for the data gathered in forest monitoring plots. There are a number of objectives that must be met by a monitoring database or management system. The system must be able to house and sort detailed information on vegetation, indicators, site descriptions, plot sizes, land uses and human impacts. This database will need to be adaptive in order to allow for the incorporation of new protocols and applicable for plot information from different environments such as marine systems. The system should be standardized so that comparisons between sites and comparisons over time can be made. The information system will also need to be user friendly in order to allow for easy data entry and analysis by a variety of different researchers, managers or community partners. Data must be able to be stored quickly and analysed in a timely fashion so that information on

ecosystem change can be used to assess potential problems. Accessibility is also important and to meet this objective EMAN CO is currently developing a series of web pages for the EMAN forest monitoring plots. Finally, the information stored must be understandable and available in order to allow for a description of biodiversity status in Canada.

5. Feedback and Communication

Monitoring can provide data that can be analysed for timely information on ecosystem change, which can then be used to better inform decision-makers leading to the creation of better environmental policies. However, in order to suggest action, we need reliable information. Assessment of current data will help EMAN keep abreast of emerging issues; we will be able to identify areas of specific interest or concern in terms of ecosystem change. This cannot happen without the establishment of an assessment and feedback network. Publications or the creation of a web site is needed to show trends and findings for forest biodiversity plot data. Data analysis of integrated forest monitoring can explore ecological relationships, assess effectiveness of management techniques and lead to better decision-making in terms of environmental protection. Along with feedback, results of the monitoring programme need to be communicated to the general public as well as to managers and policy makers.

6. Partnerships

New partners should be sought and old partnerships encouraged, as partnership is the basis for an Ecological Monitoring and Assessment Network. Along with partnerships developing with EMAN, partners need to be able to communicate directly with each other and work together to synthesis the information on an ecozone level. EMAN is also looking at expanding the network beyond a national level. Monitoring programmes have been developed in many other countries and combining information can lead to a global study on biodiversity trends and ecological change which will prove invaluable in international policy-making and protocol.

References

Roberts-Pichette, P & M. McKellar. 1996. Unpublished. EMAN'S Goals, Objectives and Deliverables: 1996 Declarations. EMAN Occasional Paper Series, Report No. 3. Ecological Monitoring Coordination Office, Burlington, Ontario.

CHAPTER 1
THE ROLE OF EMAN

HAGUE VAUGHAN

The Ecological Monitoring and Assessment Network (EMAN) was established to promote the integration of long-term, multi-disciplinary ecosystem research projects and their results across the country. A significant portion of EMAN's work involves efforts to standardize measurement protocols and to synthesis the information that is collected and reported from partners in different ecozones. This contributes to the larger objectives of making data accessible between the EMAN partners and of communicating integrated ecosystem information to decision-makers. The EMAN Coordinating Office (EMAN CO), in collaboration with its partners, provides a framework within which research and monitoring programmes to study ecosystem change can be more effectively conducted.

The forest biodiversity plot protocol originally established by the Smithsonian Institution/Man and the Biosphere (SI/MAB, now known as the Monitoring and Assessment of Biodiversity Programme) has been well supported for the purpose of monitoring changes in forest biodiversity. The establishment of plots, following the specified protocol, allows comparisons to be made over a variety of geographic areas, from local to regional or ecozone scales. The standardized protocol provides the basis for developing a consistent method of reporting change in forest biodiversity across Canada and lends itself to the study of the status and trends of specific biological variables and of ecosystem attributes. The SI/MAB protocol however is based on tropical forest systems. In order to provide for Canadian ecological areas, the SI/MAB protocols have been adapted in order to effectively measure vegetation in temperate climates.

The first Canadian SI/MAB training course was held at Kejimkujik National Park in April 1994. The course attracted interest from a variety of federal and provincial government agencies, private industry and non-governmental organizations. The primary objective was to introduce participants to the SI/MAB methodology for establishing biodiversity monitoring plots. Cooperative efforts between Environment Canada's EMAN Coordinating Office, representatives of the Nova Scotia forest industry, Parks Canada and the SI/MAB office were explored. Considerable scientific interest at the site was generated and additional projects involving individuals from the scientific and academic communities began in earnest.

Figure 1. Training course at Kejimkujik National Park.

At the time of that first training course, a goal to establish at least another ten plots in Canada was agreed upon. Seven years later, interest in the programme has increased considerably and more than 90 plots have been established across the country; from Old Growth Carolinian and temperate rain forest monitoring plots in the south to boreal plots in the north. A tremendous amount of biodiversity data has been, and is continuing to be, collected from a variety of Canada's forest ecosystems.

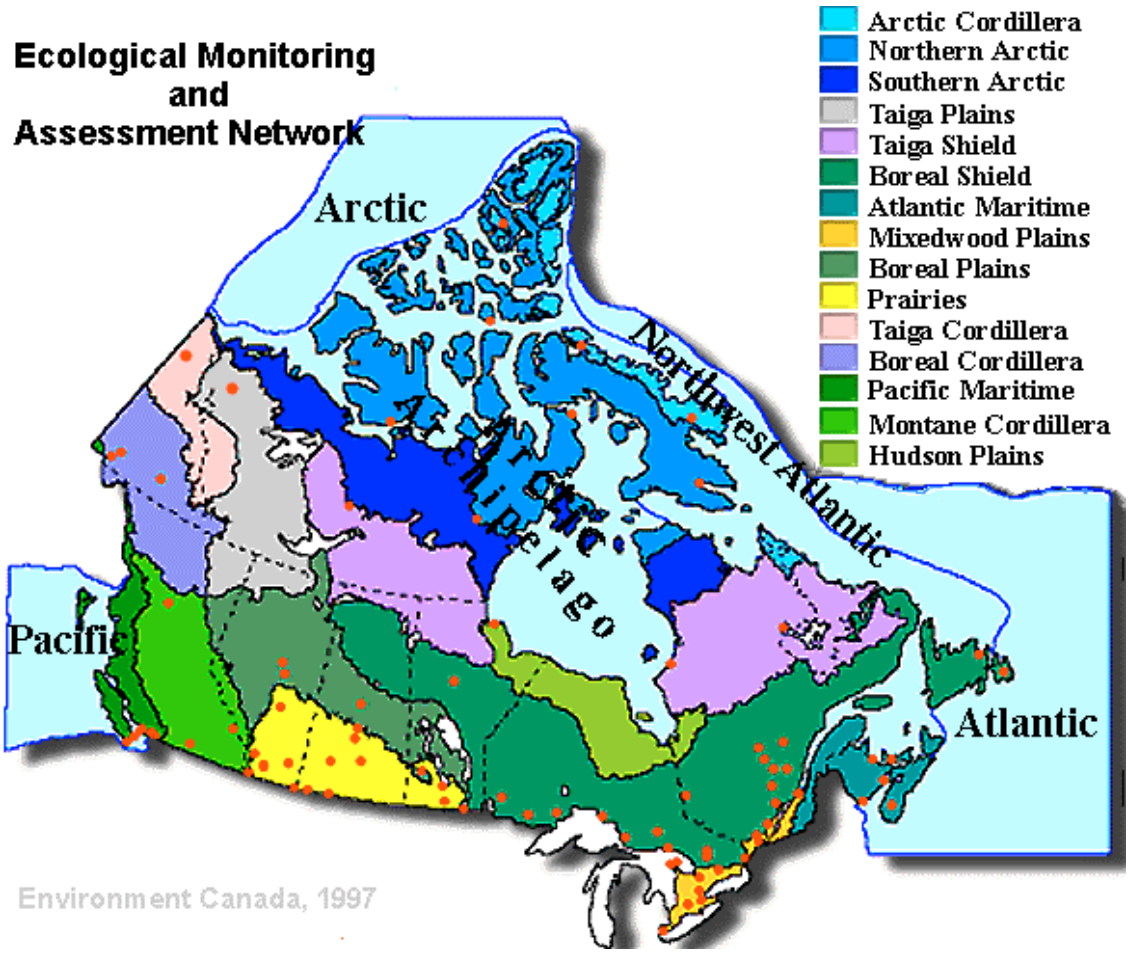

Figure 2. Distribution of forest biodiversity monitoring sites across Canada.

Since that beginning, the number of variables monitored in SI/MAB plots has expanded. The original SI/MAB protocol (one hectare plot) focused solely on the forest canopy trees and was adapted and added to by the EMAN CO Expert working group, for a more integrated approach to monitoring Canadian forest ecosystems. In turn, this work has paved the way for the synthesis of other complementary standardized monitoring protocols. This publication, in part, illustrates that evolution, from SI/MAB tree monitoring plots to EMAN biodiversity plots.

A major factor in that evolution has been the EMAN Terrestrial Vegetation Monitoring Protocol paper, which introduced the concept of scale and expanded the original base of monitoring protocols to include the lower forest strata, e.g. shrubs and ground vegetation in forest and non-forest ecosystems.

The Terrestrial Vegetation Monitoring Protocol paper had three major simultaneous developments. One addition to the SI/MAB protocols was the use of an optional plot size (20 x 20 m) along with the 1 hectare plot size for monitoring forest canopy trees. Canadian forests generally have fewer species of trees than tropical forests therefore, depending on the research goal, an alternative plot size could be used. The 20 x 20 metre plots can also be used in conjunction with the 1 hectare plots to allow for the gathering of additional information. For example, the 1 hectare plot set up in the Niagara Escarpment can be used as an ecological description of the area while 20 x 20 metre plots can be scattered throughout the biosphere reserve to monitor changes along gradients, urban areas, or specific indicators answering a particular research question.

An ideal monitoring programme would include both 1 hectare plots and several 20 x 20 metre plots in order

to maximize the amount of data collected on ecosystem status and change.

Another development was to expand the original SI/MAB protocols to include monitoring of other levels of vegetation - shrubs and saplings, and ground vegetation. This expansion allowed for the development and incorporation of additional protocols such as: tree health, worms, frogs, salamanders, lichens and arthropods. These additional protocols are discussed in Chapter 3.

A third development was the standardized definition of a tree as opposed to a sapling for classification purposes. This poses several problems as Canada is home to a variety of forest types including dwarf systems and northern slow growing systems. In the Terrestrial Vegetation Monitoring Protocols two different measurements are given in order to classify an individual as a tree. In most Canadian forests trees are those individuals with a diameter at breast height (dbh) of 10cm or more. The dbh changes to 4cm when classification in being done in a dwarf forest system. However, there may be a need to add in a third measurement in northern slow growing systems. In the Wolf Creek Research Basin, dbh for trees was measured at 2.5cm and above, as these individuals can be 10-20 years old. The majority of those participating in the Network are continuing to use define a tree as one above 4cm dbh as recommended in the original SI/MAB protocol.

The adoption of a standardized set of biodiversity monitoring protocols has enabled EMAN partners to collect baseline data that can be used to assess the effects of large-scale ecosystem stressors. This data is essential in order to better understand the effects of major climatic events, increasing pollutant levels, fragmentation, invasive species, increasing levels of UV-B radiation and other stressors (alone or in combination) on Canadian ecosystems. An integrated system for the interpretation and assessment of the direct and cumulative effects caused by ecosystem stressors across the country is essential, and will help EMAN to appropriately promote the formulation of sound policy and decision-making for sustainable development throughout Canadian society.

Ultimately, the purpose of this publication is two-fold:

1. to encourage the expansion of biodiversity monitoring in Canada - to show how the original SI/MAB concept has evolved and expanded in Canada to incorporate biodiversity monitoring of forested and non-forested systems as a whole and;
2. to provide a forum for participants to share information and data, their successes and challenges and to acknowledge their contributions in building an effective Canadian biodiversity monitoring programme.

This publication was created in order to summarize the work already completed and commend those already participating in the forest biodiversity programme; showing how it started, how it changed, where we are now, and based on this, where we should go from here. This publication also aims to encourage the expansion of biodiversity monitoring programmes with the addition of new protocols and in establishment of more biodiversity plots in a mixture of areas throughout Canada in order to provide a national view of ecological health and change.

By collecting and sharing information on what has been studied to date, this report recommends a direction in which to go: identifying gaps in our knowledge; identifying how to fill those gaps; and developing a system of data collation, analysis and dissemination of information. In essence, the use of these plots is evolving far beyond the original expectations into an integrated ecosystem monitoring network that provides consistent information to facilitate the adaptive management of sustainability from local to national scales. None of this could have happened without the time and resources volunteered by concerned citizens and community partnerships that have brought us this far and upon which we will continue to depend. This review is therefore also a celebration of how far we have come.

Communicating Results

One of the most important aspects in developing a nation-wide monitoring programme is incorporating an efficient and timely method of disseminating information: data, general trends, specific analyses and directions for the future. This is essential in order to ensure that participants contributing time and information know that the information they have collected is being analysed and incorporated into something larger.

For the past few years, the EMAN website has served as a repository for data summaries for some of the Canadian and a few international SI/MAB forest inventory sites. While this has been a successful beginning, we are now building and expanding on what has been started.

Using a forum, such as this publication, gives community monitoring participants an idea of what is known and what directions are to be taken. Through this publication, information is collected and united into one form, a bit of information about each site is given, and access to both data and data analysis is provided. Data, collected by individual sites, has been collated and analysed specifically for this publication, to establish baseline knowledge and to identify areas of weakness.

Long-term monitoring programmes rely heavily on the interest and continued participation of dedicated professionals and community partners who commit time and resources often on a voluntary basis. It is necessary to show that the information being collected is not going to waste; that it is being studied and analysed, weak links are identified and action is being taken to make the programme stronger. Without encouragement and feedback, participants may lose interest. Sites that continue to thrive will do so of their own initiative and the focus of the programme will switch from a national to a local level. If that happens, it will be hard to convince partners to become involved in a similar national programme once again. By clearly defining our objectives and building on what we have, we can encourage current participants to continue and encourage new participants to join.

It is important to involve and educate Canadians on the current state of the environment and on what is changing. The network of EMAN forest monitoring plots, which collects large amounts of data on a wide variety of forest ecosystems, has an obligation to provide access to that information (data and subsequent analysis) and to deliver that information in a timely manner to encourage future participation and informed decision-making.

Linking and Implementing the Canadian Biodiversity Strategy

The management of biodiversity is an issue that affects the quality of life of all Canadians. Human societies and regional economies are tied to resources produced by ecosystems. The impacts of change in ecosystems are expressed through shifts in biodiversity. Shifts in biodiversity alter the resource base of regional economies often to the detriment of human populations. Sound ecosystem management is key to sustained resource utilization, dynamic regional economies and long-term maintenance of human populations. Improvement of the quality of life for Canadians demands a national effort to acquire realistic information on our biological diversity (EMAN Biodiversity Science Board, 1997).

The Canadian Biodiversity Strategy stressed the need to improve our understanding of ecosystems in an effort to improve our planning and management capabilities. The attainment of this goal is based primarily on ecological management, defined in the Strategy as “the management of human activities so that ecosystems, their structure, function, composition, and the physical, chemical, and biological processes that shape them, continue at appropriate temporal and spatial scales” (Biodiversity Convention Office, 1995). Integral to improving our ecological management capabilities are: biological inventories, data and information management, training and monitoring.

Sustainable management of biodiversity depends on the availability of realistic information about ecosystems. Monitoring programmes assembled within the context of baseline inventories can provide that

information (Biodiversity Convention Office, 1995). EMAN has implemented or assisted with the development and implementation of a number of monitoring programmes across Canada. Information on biodiversity and how it's changing can be collected through the adoption of standardized protocols such as;

- EMAN Terrestrial Vegetation Monitoring Protocols;
- Wormwatch (to monitor and assess change in earthworm population and distribution);
- Frogwatch (to monitor the presence and absence of frog species) and;
- Plantwatch (to monitor flower phenology).

Subsequent national monitoring programmes (e.g. salamanders, birds, lichens, benthic invertegrates) that may be used to collect information in association with the EMAN forest monitoring plots are currently being tested.

The current protocols have been designed to fill a variety of purposes in relation to research, education and conservation. The EMAN monitoring protocols can meet the needs of individual researchers or organizations. They can also play a role in larger management programmes. For example, EMAN monitoring protocols can be used for National Park monitoring projects in order to be able to detect issues of concern within a national park or to identify problems in meeting the objectives of the park's management plan. These protocols also allow for co-ordination with provincial park managers and researchers in order to build on previous projects or future monitoring and management plans.

The inventory protocols outlined in the EMAN Terrestrial Vegetation Monitoring Protocol document are specifically designed for both forested and non-forested systems in Canada. The groundwork has been laid for the development of future biological inventorying protocols and to establish the need to link biological inventory data with biophysical factors (soil, climate, etc.). To date, forest inventories using SI/MAB or EMAN protocols, are being conducted in vulnerable and protected areas (National and Provincial Parks, Biosphere Reserves), critical habitats (northern Canada), areas with taxonomic groups of economic importance (Mont St. Hilaire, CARE), areas of high diversity (Long Point, Niagara Escarpment) and areas where human development and disturbance are the most significant (southern Ontario, coastal British Columbia).

A significant portion of the EMAN's work involves efforts to standardize measurement protocols and to ensure that the information collected using those protocols is made accessible between the EMAN partners. By broadening the base of information collected on forest biodiversity (from inventories of canopy tree species to inventories of above-ground vegetation layers, fauna, soils, etc.), we are implementing the means to enhance the collection, sharing, analysis, scope and distribution of data and information required to monitor biodiversity.

The successful implementation of the Canadian Biodiversity Strategy depends on the support and participation of National and Provincial Parks, Conservation Authorities, educational institutions, local school groups, government agencies, research institutions, conservation groups, industry, local communities and local individuals - all of whom are partners within the EMAN network of forest monitoring plots. This network is a means to unite a variety of interests toward the common goal of biodiversity conservation.

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Figure 1 Training course at Kejimkujik National Park
Figure 2 Distribution of forest biodiversity monitoring sites across Canada

CHAPTER 2
MONITORING BIODIVERSITY IN CANADIAN FORESTS

KRISTI SKEBO

EMAN Terrestrial Vegetation Monitoring Protocols

Long term ecological monitoring is the way to document what is changing in plant ecosystems, at what rate and with what results. It should give warning of what is likely to happen (based on documentation of what has happened) and thus allow for preventive or adaptive action.

The long term monitoring protocol, established by Smithsonian Institute (SI) and the United Nations Educational, Scientific, Cultural Organization (UNESCO) Programme on Man and the Biosphere (MAB), was a suitable method for monitoring the diversity of mature forest tree species in tropical systems, but how would this translate to monitoring in Canadian forests?

The Terrestrial Vegetation Monitoring Protocols have been adapted from the SI/MAB protocols to suit Canadian ecosystems. These protocols are a set of robust methods recommended for long term monitoring of plant species diversity in forested and non-forested ecosystems in Canada. The use of these protocols enables observers to document changes in species (abundance, richness and community structure) and therefore changes in ecosystems over the long term. These protocols are to be used in conjunction with protocols for monitoring other terrestrial organisms living above or below ground, and for monitoring selected climatic and other abiotic variables. Studies of a variety of long-term data sets, each using the same standard methods, should provide insights about change over broad regions, raise questions for additional research, and/or help define or circumscribe unexpected environmental problems.

The focus of the Terrestrial Vegetation Monitoring Protocols is the above ground vegetation components of forest and non-forest ecosystems. The Manual provides information on canopy trees, small tree stratum, shrubs, and ground vegetation in terms of;

- Permanent plot establishment (how to decide on the number of plots, how to randomly select plot positions, how to survey a permanent monitoring plot, etc.);
- Record keeping;
- Data/Information collecting methods (how to find and identify terrestrial vegetation, how to number/tag trees, how to measure dbh, how to map trees, etc);
- Data compilation and processing; and
- Model data sheets.

In forest communities, the monitoring of canopy and understory species in conjunction with saplings, shrubs and ground vegetation will provide data on the influence of the canopy upon the rates of recruitment of seedlings into the understory. It can also give hints about how the structure of the upper forest strata is likely to change in the future, and will provide insight into the different drivers of change. Such information may help to separate innate variation from that driven by climate or other global change, as faster results on population changes are likely to be achieved from monitoring species in the vegetation strata. Similarly, in non-forested communities, monitoring data should give insight into the dynamics of vegetation patches. Shrub and sapling data are particularly important when monitoring or managing valued wildlife species. Ground vegetation species are finely tuned to their environment. Because of their numbers, they will yield a rich data base for analysis on the dynamics of species in response to environmental changes brought about by shifts in the concentrations of airborne pollutants, increased in UV-B radiation, and the variability of temperature and moisture regimes. Monitoring what is happening in non-forest ground vegetation species together with forest ground vegetation species, may provide indications of environmental change more rapidly than forest trees alone.

The Biodiversity Assessment Team in 1994 stressed that monitoring biodiversity change involves understanding some fundamental concepts such as scale, type and indicators of change, the relationship between stability and diversity, and habitat fragmentation, etc. Scale is crucial when dealing with biodiversity. Questions dealing with the measurement, monitoring, values and causes of biodiversity change may have different answers depending on the spatial and temporal scales at which a question is asked or answered. It is therefore, important to adopt a hierarchical approach with lower levels of diversity (e.g. genetic) being aggregated to higher levels (e.g. species populations, ecosystems). Actions at one level will have ramifications at both higher and lower levels. This must not be underestimated when planning, executing and interpreting the results of long-term monitoring of biodiversity change, especially as it applies to the species and ecosystem levels.

In 1994, EMAN selected the square, one-hectare plot size (subdivided into twenty-five 20 x 20 metre quadrats) as a standard for monitoring the biological diversity of trees in Canadian forest ecosystems. The one hectare plot (also known as the SI/MAB plot), is recommended in Canada for the major long term research and monitoring projects of forested ecosystems. The use of a one-hectare plot gives a relatively large sample and, therefore, is likely to be reasonably representative of the selected stand with respect to spatial relationships of the species, patchiness, tree fall, ages of trees, species composition, etc. Since 1994, monitoring protocols have continued to evolve.

Experience with the 1 hectare plot has demonstrated that a smaller plot size is also needed in conjunction with or as an alternative to 1 hectare plots. Table 1 gives a benefit-cost breakdown for the single hectare plot versus the 20 x 20 metre plot size. However, many programmes would profit from the use of both plot sizes in order to meet research or monitoring needs.

20 x 20 metre plots	1 hectare plots
Benefits: - An alternative to 1 hectare plots when there are time, resource and/or monetary constraints. - Can monitor dense, even aged stands of trees with dbh generally below 10 cm; - Monitors dwarf forests with most trees under 10 cm dbh; - Used to Monitor forests where a limited number of tree species reach canopy; - Used to monitor in irregular stands; - Monitors specific biotic/abiotic factor for pre-designed experiments; - Indicator-specific monitoring; - Good management tool allowing for adaptive planning through biological monitoring; - Cost effective; - Simpler design; - Gives timely information on ecological changes; and - Easy to use in community based monitoring programmes. *Costs:* - May not provide a representative example of ecosystem under study unless species curve has been properly applied; - Can limit capacity for multiple research purposes; and - Can limit information on biological processes.	*Benefits:* - Provides a solid ecological description of community; - Better quality information limiting sampling error; - Can monitor areas with large numbers of species; - Can stretch across changes in soils, topography and water supply; - Can allow for a variety of research interests and/or goals; - Allows for information on a variety of indicators at a variety of scales; - Elevates the importance of a study area - Access for larger groups; - Good for educational or training programmes; *Costs:* - More labour intensive; - Higher cost; and - Can slow feedback process due to the amount of data collected.

Table 1. Benefit-Cost analysis of plot sizes in Canadian monitoring projects.

The minimum number of 20 x 20 metre quadrats in any stand is probably five in forests with few canopy tree species e.g. coniferous or trembling aspen forests, and ten in hardwood or mixed wood forests (Roberts-Pichette & Gillespie, 1999). A species accumulation curve (Figure 1) can be used as a guide to decide if this number is sufficient for a particular stand. A thorough description of the species accumulation curve is given in the protocol. The methods included in the manual are not meant to supersede methods already in use (unless current methods are found to be wanting in some respect). Given that long term

biodiversity monitoring is so rare in Canada, it is far more important to continue with a monitoring programme with original methods than to change to newly recommended ones.

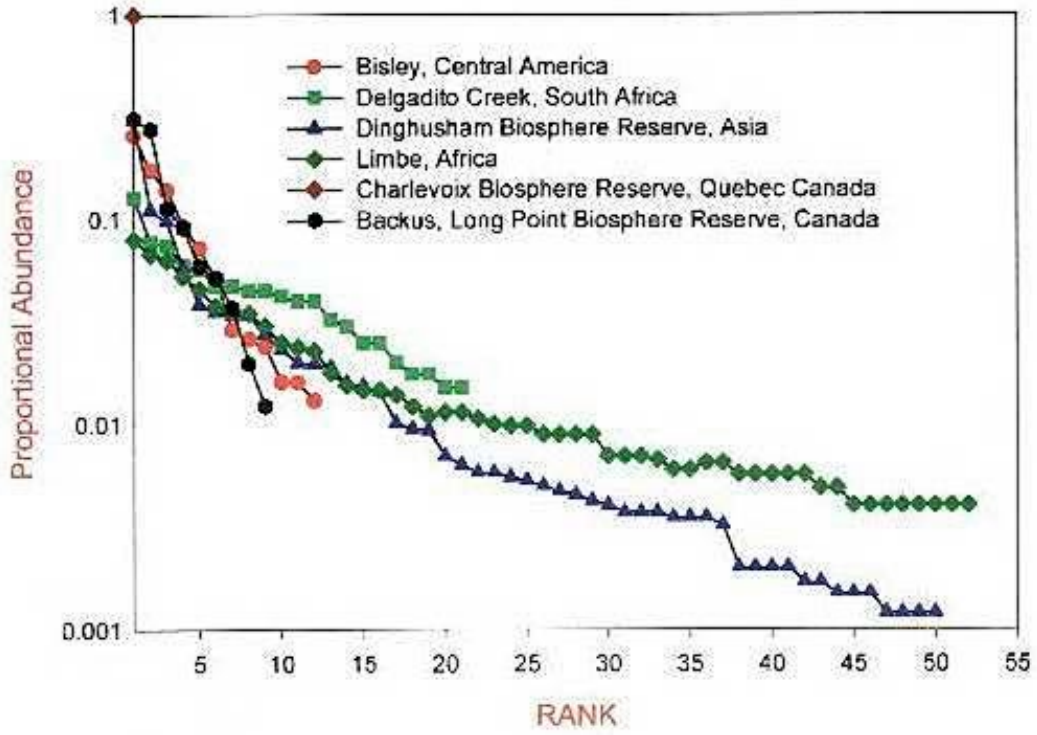

Figure 1. An example of a tree species accumulation curve to determine the number of plots needed to represent a natural community.

Data from one large plot in a single stand, while invaluable for a specific site has to be combined with data from other sites to obtain maximum benefit at local, regional and national scales. It is essential for groups within the same ecozone to consult and cooperate with one another when establishing biodiversity monitoring programmes; to coordinate activities and pool data. Expertise sharing, and the integration and synthesis of data from the same community type for analysis and interpretation should be encouraged. This will facilitate the formulation of scientific interpretations that are applicable to a wider geographic area. Standardization and sharing of data will also help validate the results from individual sites, provide more reliable estimates of change or stability in tree diversity within or across community types in an ecozone, and provide a base for comparison across ecozones. Over the long term, this approach will help distinguish local effects from those occurring over a broad spatial scale.

What sets this forest biodiversity monitoring programme apart from other research or data collection programmes is the quantitative data that is being collected - only that which can be counted or measured is recorded. This will allow for the participation of community partners with differing levels of experience to collect reliable data as it is not based on judgement or estimation. Estimates are not used in the field, even though indices or scales may be derived from the data collected. Everything must be documented. This precision is what will prove to be very valuable in the long run.

When undertaking a project using the Terrestrial Vegetation Monitoring Protocols, the manual can guide managers and participants of a monitoring programme through all the necessary procedures involved in terrestrial vegetation monitoring. Table 2 lists the general steps required in carrying out a monitoring plot programme.

Actions	Description
Size/Number of Plots	Choose a plot size or a combination of plot sizes needed to meet management or research objectives.
Site Selection	Use random site selection in order to pin point area of study within preferred ecozone or natural area.
Resource Preparation	Ensure that all equipment and necessary people are assembled and available to complete the monitoring process.
Data collection	Follow protocols for the measurement and collection of data in and around the plot(s).
Data Compilation and Archiving	Compile data, ensure that the information is saved in an understandable format (such as BioMon) to allow for research or long-term comparison.
EMAN notification	Work with EMAN in order to be part of Canada's monitoring and assessment network.

Table 2. List of actions to be taken when monitoring biodiversity using EMAN protocols.

The Terrestrial Vegetation Monitoring Protocols manual, by Patricia Roberts-Pichette and Lynn Gillespie can be found on the EMAN website at;
(English) http://www.eman-rese.ca/eman/ecotools/protocols/terrestrial/vegetation
(French) http://www.eman-rese.ca/rese/ecotools/protocols/terrestrial/vegetation/

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Table 1 Benefit-Cost analysis of plot sizes in Canadian monitoring projects.
Table 2 List of actions to be taken when monitoring biodiversity using EMAN protocols.

CHAPTER 3
ADDITIONAL PROTOCOLS

BRIAN CRAIG, SARAH QUINLAN & KRISTI SKEBO

In order to begin to understand the functioning of various forest ecosystems, it is necessary to accumulate information on as many aspects of these systems as possible (biodiversity). Currently, most sites are only collecting information on the various levels of vegetation within the EMAN forest monitoring plots. While this information is useful over the long-term, the effects of changes in climate or in the extent of human impact are often seen more quickly in other aspects of the forest ecosystem (i.e. those organisms with shorter growth and reproductive periods and shorter generation times). Therefore, it is important that additional protocols, which can help us monitor changes (in abundance and distribution) in other, faster adapting organisms, are adopted.

The EMAN CO, in cooperation with its partners, has developed or modified existing protocols, which can be used with the EMAN forest monitoring plots. The EMAN CO has been focusing on developing a set of standardized ecosystem monitoring protocols (EMPs) that will work together as a suite, to detect and track ecosystem changes over time, and which can be used in protected areas and working landscapes. A suite of about twenty EMPs have been selected that:

- will identify significant changes in ecosystems beyond normal ranges of fluctuations, so as to trigger and guide the design of future more rigorous investigations;
- are suitable for measurement and comparison among a variety of sites;
- are characterized by cost effective sampling methods; and
- will easily fit into existing monitoring programmes. (Environment Canada, 2000a)

The EMPs were distilled from 1770 monitoring variables assembled from a variety of sources including major environmental monitoring programmes around the globe. The variables were subjected to efficacy testing to ascertain their response to a variety of issues including: Endocrine disrupters; Invasive species; Global carbon cycle changes/Global climate warming; Increased Ultra Violet "B" (UV-B) radiation; Habitat fragmentation; Transportation corridors; Acid rain; DDT; Eutrophication; Ground-level ozone; Pulp and paper mill effluent; and Groundwater contamination (Environment Canada, 2000b).

The majority of the selected variables are quite responsive to most of the stressors but redundancies and gaps were identified through this process and the suite was altered appropriately. The suite of core monitoring variables are listed in Table 1.

Several EMPs can provide multiple measures of ecosystem change. For instance, measuring species diversity of frogs also provides measures of morphological symmetry, species richness, and exotic species. The total number of field measures can therefore be reduced while retaining the capacity to measure different aspects of ecosystem change. There is general consensus among the EMAN partners that this suite is a suitable starting point for the tracking and early detection of ecosystem change. The suite will no doubt evolve, as pertinent new information on ecosystem changes becomes available.

An impediment to making comparisons at varying scales has been the lack of availability of comparable data: this can be addressed through development and implementation of standardized ecosystem monitoring protocols. EMAN is making a concerted effort to use, adapt and develop standardized monitoring methods for each of the EMPs and for other aspects of ecosystem monitoring as opportunities arise.

	Core Monitoring Variable	Derived Measures
1	Water quality – dissolved oxygen	
2	Water quality – water clarity	
3	Stream flow – stream flow rate	
4	Lake level – lake level fluctuation	
5	Air quality – lichen indicators	
6	Temperature mean – soil temperature/permafrost depth	
7	Snow/Ice phenology – lake ice out / ice in timing	
8	Lake sediment – sediment core analysis	
9	Species richness – amphibians	MS,RS,ES
10	Species richness – mammals	RS,ES
11	Species diversity – birds	RS,ES,SR
12	Species diversity – plants	RS,ES,SR
13	Species diversity – frogs and salamanders	MS,RS,ES
14	Species diversity – aquatic invertebrates / benthos	RS, ES, SR
15	Community biomass – benthos	
16	Indicator species group – fish Index of Biotic Integrity	MS, RS, ES, CB, CP, GP
17	Land cover change	
18	Plant phenology	
19	Community productivity – phytoplankton	
20	Community productivity – plants	CB
21	Soil health – earthworm species richness and soil decomposition	
22	Tree health – crown and bole condition	

Table 1. List of core variables recommended for monitoring programmes. (Abbreviations used: MS – morphological symmetry, RS – rare species, ES – exotic species, SR – species richness, SD – species diversity, CB – community biomass, CP – community productivity, GP gross pathology.).

EMAN, in partnership with the Canadian Nature Federation, has established a series of NatureWatch programmes that are designed to collect reliable information that can contribute to local, regional and national monitoring programmes. Many of the protocols discussed below are part of the NatureWatch programme. The focus of NatureWatch is to encourage the cooperation of community partners in order to expand geographic coverage and augment the frequency of observations. Though the protocols in NatureWatch have been designed by scientific experts for validity and reliability they are also laid out simply and available for use by people with varying degrees of monitoring experience. Therefore monitoring project managers can expand the capacity of local monitoring information collection by engaging the broader community.

The use of community partners can be incorporated into all of the recommended protocols though some require participants to have a certain level of experience mostly involving species identification. Properly designed training courses will help to ensure that the collection of information is accurate.

Protocols are designed to meet local needs but will contribute provincial and national information. Therefore, though individual site managers will be maintaining their own database, it is important that the data is shared through EMAN in order to track changes on a larger scale. For many programmes, information can be submitted via the EMAN or NatureWatch websites and is then available for use by EMAN and its partners.

The protocols discussed below are those recommended for use on their own, as part of a monitoring programme or in association with all EMAN vegetation plots, as they are relatively inexpensive to implement and are easily repeatable from year to year. While these protocols should be used in sections of the forest stand that are similar in composition to the EMAN forest monitoring plot, most of the actual sampling should not occur within the plot itself. Too much traffic in the vegetation plots will result in the study of the effects of people on the plots as opposed to the effects of environmental change on the vegetation being monitored. As shown in figure 1, additional protocols can be easily related to 20 x 20 metre plots.

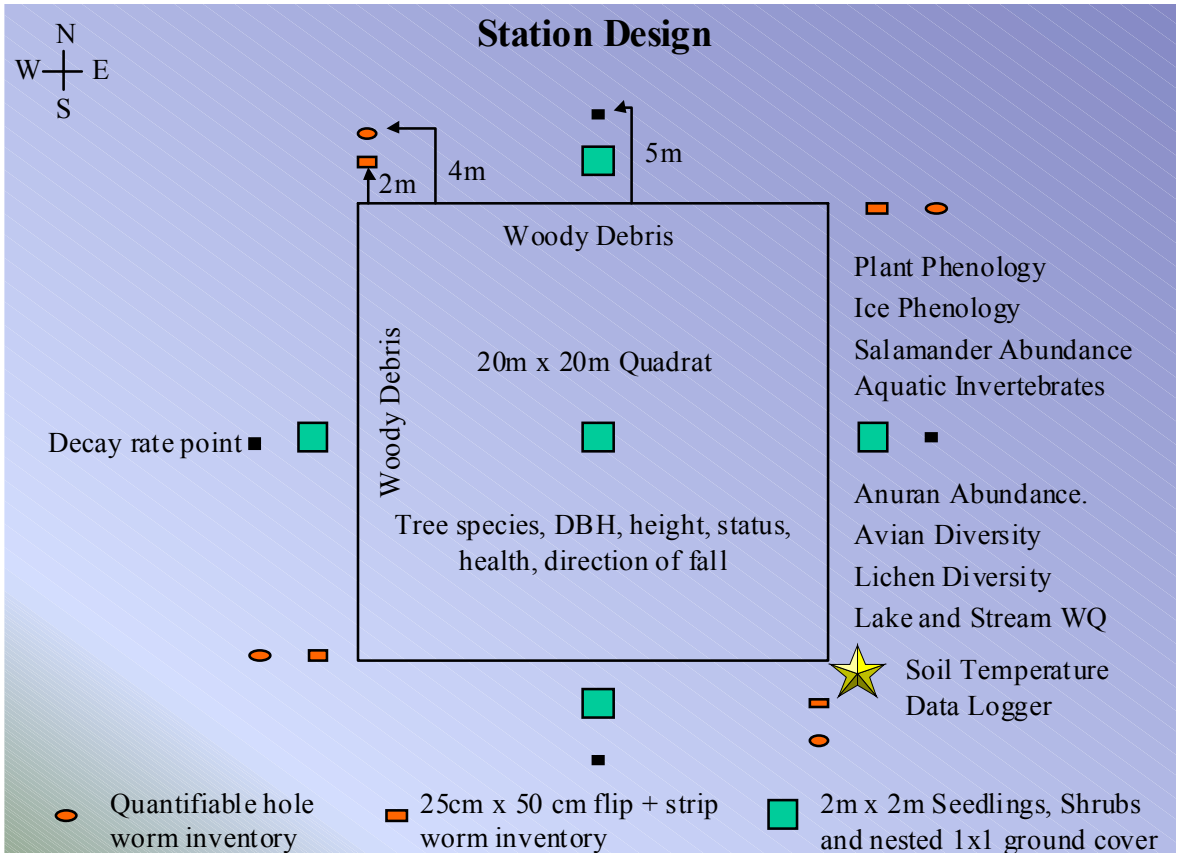

Figure 1. An example of a 20 x 20 metre plot with additional protocols.

Tree Health

This protocol has been developed in partnership with the Canadian Forest Service to monitor tree health by recording tree crown conditions and stem defects.

Long-term monitoring on the defects and crown condition of trees can give useful information on ecosystem health within Canadian forests. Tree age, size and disturbance history are all essential pieces of information. Short-term stress factors such as insect defoliation or weather extremes may cause dieback, but when the stress is removed, the trees should recover. Prolonged stress factors may result in dieback and decline, and possibly in whole tree mortality. By recording crown conditions and stem defects, the levels of damage on a variety of age or size classes may be understood.

Information on tree crown status and defects can be easily added to a forest biodiversity monitoring programme for trees within a plot. It involves the identification of status, crown class, stem defect and crown condition. Community partners who undertake an annual training session can do these simple assessments. The training session is done in order to provide consistency in tree health determination.

Tree health protocols and data sheets can be found at http://www.eman-rese.ca/eman/ecotools/protocols/terrestrial/.

Arboreal Lichen Abundance and Diversity

This protocol is being developed by expert lichenologists including Dr. David Richardson, St. Mary's University and Dr. Irwin Brodo, Canadian Museum of Nature. It will record the abundance of easily identifiable lichen species and include information on how samples are taken for subsequent chemical

analysis of metals and organic pollutants.

There is a strong relationship between arboreal lichen communities and air quality. Lichens are sensitive to air pollution, especially sulphur and nitrogen based pollutants (Richardson, 1992). These organisms are important ecologically as they are used for nesting material, habitat and are foraged by many forest species.

Different tree species harbour different lichen communities; consequently suites of lichens are being developed for monitoring air quality in mixed hardwood forests, boreal forests, and temperate rain forests. Trees within the forest plot and in an adjacent forest edge are selected. The percentage of the specific suite of species found between 1 and 1.3 metres on the trees are recorded. The protocol also specifies a method for collecting lichen samples for chemical analysis.

Preliminary protocols can be found at http://www.eman-rese.ca/eman/ecotools/protocols/terrestrial/.

Salamander Abundance

This protocol is being developed in cooperation with Parks Canada, Ontario Parks, Canadian Amphibian and Reptile Conservation Network, United States Geological Survey and other amphibian monitoring experts. Salamander monitoring consists of compiling information on species presence and abundance in a predetermined area over time to establish trends.

There is very little baseline information on salamander populations in Canada. Salamanders are an ideal subject in monitoring programmes as they are territorial and therefore responsive to local changes. Salamanders are good bioindicators for acid rain, sedimentation, contamination and habitat change.

The protocol consists of a series of wooden boards, providing cover for salamanders, placed adjacent to forest monitoring plots. Once established, they are checked for eight weeks on a weekly basis in autumn. Species information is recorded for individuals found under each cover board. This method of "capture" provides an index of salamander abundance in the area. Relative changes in abundance can be determined after a few years of sampling. Though this requires species identification the protocols are relatively simple and sampling is easily initiated by community partners.

Salamander monitoring methods, data sheets and data entry forms are at http://www.eman-rese.ca/eman/ecotools/protocols/terrestrial/.

Earthworm Diversity

WormWatch is a programme established by Dr. Jill Clapperton of Agriculture and Agri-Food Canada, in cooperation with EMAN and the Lethbridge Research Centre, to assist in identifying the various species of worms and their distribution in Canada.

Earthworms are good indicators of soil health as they are sensitive to disturbances. They are also good indicators of soil diversity as they affect everything from bacteria in soil to flora and fauna above soil. The measurement of the diversity of earthworms can be used in habitat management and information found can lead to the improvement of site reclamation and soil remediation techniques. Little is known about the diversity of earthworms. In fact the majority of earthworms in Canada are exotic species introduced by European settlers. This NatureWatch programme will help to determine the distribution of earthworms in Canada as that information is currently unknown.

Figure 2. Earthworm.

Figure 1 shows the location of worm stations in relation to a 20 x 20 m quadrat. The original protocols have been adapted specifically for use with EMAN forest monitoring plots and include specific instructions on sample collection. Stations should be outside the plots as it requires some digging and soil disturbance in order to locate earthworms. Community partners are able to carry out these monitoring protocols after they have learned identification and sampling techniques.

The protocol, species key and other photographs can be found at http://www.wormwatch.ca/. Data collected from the forest monitoring plots can be entered directly onto the WormWatch website.

Annual Rates of Decay

This protocol has been used by the Canadian Forest Service (Pacific Forestry Centre) to monitor changes in decay rates in soil.

Measuring annual decay rates will provide a good indicator of changes in soil health; specifically with respect to changes in soil respiration and microbial activity - elements that are primarily controlled by soil temperature and moisture and to a lesser degree soil type and plant community.

Measuring rates of decay involves recording the loss of weight in buried aspen tongue depressors or chopsticks over time. Annual rates of decay can be done in conjunction with forest biodiversity monitoring. Testing sites can be located adjacent to a monitoring plot and flagged. Measuring the rate of decay involves the placement of 4 pairs of preweighed aspen depressors or chopsticks in the ground, usually in autumn. They are then removed exactly one year from the placement date and reweighed to determine decay.

Protocols and data sheets can be found at http://www.eman-rese.ca/eman/ecotools/protocols/terrestrial/.

Plant Phenology

This NatureWatch programme has been developed in cooperation with plant phenology experts in each province and territory throughout Canada. This protocol records the blooming time of a suite of plants responsive to changes in climate.

Tracking bloom times provides information on climate variability and change.

The monitoring of blooming times can be done in areas adjacent to the plots that contain individuals that are part of the suite of species for the province or territory. Several sites can be marked each containing one or multiple populations of suite species. Monitoring is done from early spring to record the dates of first blooms and mid blooms for each species as specified by the protocol. This protocol can be undertaken by naturalists or persons familiar with plant species attributes.

The provincial protocols, datasheets and data entry forms for PlantWatch can be found at http://www.plantwatch.ca.

Anuran Species Richness and Calling Phenology

The frog and toad monitoring protocol was developed in cooperation with the Canadian Amphibian and Reptile Conservation Network (CARCN) and expert herpetologists across Canada. This protocol monitors the presence or absence and abundance of frogs and toads through call identification.

Amphibians have permeable skin, which means that they are sensitive to the addition of toxins to their water environment. The organisms are also sensitive to alteration in climate, Ultra Violet radiation and atmospheric changes, making them a good indicator species for monitoring programmes.

A permanent listening station should be established in the nearest wetland adjacent to a forest monitoring plot. Listening should be done on a weekly basis or as frequently as possible especially between the months of March and July, depending upon the geographic location of the site.

Anuran species richness and calling phenology is being promoted as a provincial NatureWatch programme. The FrogWatch website http://www.frogwatch.ca includes a scientifically valid protocol, sound files for identification, a self testing programme, a geographic locator programme and online data submission.

Ice Phenology

This NatureWatch programme was developed in cooperation with the Meteorological Service of Canada, Dr Claude Dugay of Laval University and other cryosphere experts in Canada. This protocol records the freeze-up and break-up dates of rivers and lakes.

Ice cover is important biologically as it can affect water temperature, water chemistry, breeding, bird migration and food supplies within a riparian system. Therefore changes in ice cover throughout northern ecosystems can have serious impacts. Data on ice phenology is being used to track causes and effects of climate warming.

A permanent ice observation station should be established by the nearest water body adjacent to the forest monitoring plot. A concerted attempt should be made to determine the exact day of freeze-up and break-up.

This simple NatureWatch protocol is available on line at http://www.icewatch.ca and includes a geographic location programme and online data submission.

Exotic and Invasive Plant Abundance

Exotic and invasive plant monitoring protocols involve the recording of presence or absence of exotic or invasive species in predetermined areas.

Exotic or weed species that are able to successfully compete with native vegetation to form dominant growths in natural habitats are considered to be invasive. Monitoring of these problem species can act as a good indicator of ecological stress and/or disturbance to environmental processes. Invasive plants can disrupt natural areas by displacing native communities, interfering with natural functioning, and impacting native biodiversity. Increasing our understanding of problem species can lead to improved natural areas management.

Exotic and invasive plants can be monitored in a variety of ways including the recording of occurrences, abundance, expansion and noticeable impacts. Plant species are identified and recorded along with habitat and condition information. This can be done along a trail adjacent to the plot or along a roadway in the vicinity of the plot or wherever an invasive plant population has been found.

More information on how to monitor exotic and invasive plants can be found on the EMAN website at http://www.eman-rese.ca/eman/ecotools/protocols/terrestrial/exotics/intro.html.

Aquatic Invertebrate Abundance

Partners participating in the development of this protocol include federal agencies such as the Department of Fisheries and Oceans, National Water Research Institute, provincial agencies, academic institutions and Environmental Non-Government Organizations (ENGOs). This protocol will be used to monitor presence and abundance of invertebrates in streams, rivers and lakes.

The monitoring of waterways can help to pinpoint pollution problems, evaluate trends and assess the effectiveness of management or restoration projects. Aquatic invertebrates are good indicators of stream

health and water quality.

Numerous aquatic invertebrates monitoring protocols are in use by various government agencies and ENGOs across Canada. Although similar in nature, subtleties in sampling collection and sample analysis preclude comparisons of similar initiatives. There is a need for standardized protocols to allow for local, regional and national comparisons. EMAN is currently coordinating the development of standardized aquatic invertebrate monitoring protocols.

The protocols will involve the establishment of permanent sampling stations in streams, rivers or lakes. This can be done in waterways in the vicinity of monitoring plots. There are several methods of aquatic invertebrate sampling mostly involving shoreline collection or wading in 1 metre deep water for collection. Collected samples are then preserved and identified. Community partners can easily do the sample collection though identification will have to be done by persons familiar with invertebrate taxonomy.

Contact the EMAN office for more information.

Terrestrial Invertebrate Richness and Abundance

Arthropod monitoring involves the collection and recording of information on ecological groups at a series of sampling stations.

Arthropods are the most diverse group of organisms in most ecosystems and represent a vast resource of ecosystem information that is currently under-used. Arthropods can provide information on virtually all macro and microhabitats within an ecosystem. They cover a variety of size classes, exhibit a range of dispersal abilities and ecosystem requirements, go through a variety of life cycles, assist in mediating ecosystem function, assist in maintaining soil structure and fertility, regulate populations of other organisms, and respond quickly to changes in their environment. Information derived from arthropod species assemblages can be used to characterize accurately almost any aspect of an ecosystem.

These protocols are for both forest and non-forest ecosystems, some require destructive sampling and should not be done within a plot used for vegetation monitoring. Individual collection can be added to a Forest Biodiversity Monitoring programme as sites can be placed outside of 20 x 20 metre or 1 hectare plots. There are a variety of sampling methods ranging in expense and degree of difficulty for collection and identification of insects. Depending on the monitoring project, insects can be collected through ground or canopy sampling.

The protocols for arthropod monitoring can be found on the EMAN website at http://www.eman-rese.ca/eman/ecotools/protocols/terrestrial/arthropods/intro.html.

Plant Collections

This protocol is for the recording and collecting of plant species within a predetermined area. In order to obtain accurate records of the diversity of terrestrial vegetation, it is necessary to obtain voucher specimens of plants within the EMAN forest monitoring plots.

Examples of voucher species found inside the plot should be taken from populations outside the plot. Plant specimens are pressed, dried rapidly and then stored in the dark away from insect pests under normal levels of humidity found in temperate countries. Plants will remain in good condition for hundreds of years when stored in this manner. Most of the equipment and supplies for making plant collections can be obtained and assembled at minimal cost.

Instructions on how to make plant collections can be found on the EMAN website at http://www.eman-rese.ca/eman/ecotools/protocols/terrestrial/plantcoll/plant_collections.html.

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Table 1. List of core variables recommended for monitoring programmes. (Abbreviations used: MS – morphological symmetry, RS – rare species, ES – exotic species, SR – species richness, SD – species diversity, CB – community biomass, CP – community productivity, GP gross pathology.)

CHAPTER 4
DATA ARCHIVING

SALLY O'GRADY

Introduction

When setting up a monitoring plot in any environment it is important to note that plot set up and data collection is only part of the process. Data archiving is extremely important as it allows for assessment and research of the information gathered at the monitoring site.

One of the objectives of the Ecological Monitoring and Assessment Network (EMAN) is to provide a network mechanism for the sharing of ecological data and information on ecozone, regional, national and international levels. Sound data management standards are imperative in order to provide data and information sharing on such a wide scale. The rationale for having comprehensive data standards is to ensure continuity and to give users the ability to do comparative studies, either spatially, temporally or both, as well as long term accessibility to this data and information. What follows is a discussion on the Information Management System used at Kejimkujik National Park which is a good example of how to manage information collected in monitoring programmes.

Kejimkujik National Park Information Management System

An Information Management System, by its name alone, denotes that it is a system and a system is fundamentally a set of components that interact to accomplish some purpose. What a system does and how it is managed is dependent upon its design and objectives. The goal of the Kejimkujik National Park and Historic Site of Canada (KNP) Ecosystem Science Information Management System is to establish a structured set of processes for converting scientific data into information. With this goal in mind, our focus has been to develop processes by which data can be collected, stored, retrieved, analysed and in the future, be accessible in a useable format. The very core of this system's successes are standards and guidelines, ensuring that data will be both usable and shareable.

Documentation System

At the KNP Ecosystem Science Centre the philosophy is a simple one - record the minimum amount of essential documentation to register, understand and re-enact a research or monitoring project in its entirety, thereby maximising the value of the initial study and its data. With this in mind, the following documentation components have been developed: research proposal/permit, environmental impact assessment, data catalogue, data dictionary and report of findings. At the Science Centre these are archived together in a single binder with data and hardcopy print outs, which results in a consolidated, comprehensive product accessible for future researchers / analysts who may use the data in ways unforeseen by the original researcher. These binders are stored in a secure place with additional backups stored off site.

Research Proposals

The standardized research proposal, filled out by the researcher, describes in detail the study objectives, rationale, hypotheses, methods, access, sampling techniques, potential impacts, research experience and participating staff. This proposal is submitted to the Kejimkujik Ecosystem Science Manager and upon review, if the study fits with the parks research and monitoring needs, an environmental impact assessment is initiated. Upon completion of an environmental assessment, the project can start. Conditions for approval for research include researcher: agreeing with all mitigating measures or conditions identified by the environmental assessment; liasing with park information management staff on all data management and documentation standards; leaving a complete set of data and documentation in digital and hardcopy format;

and participating in project evaluation. It is advantageous in this process to have a knowledgeable person on site who can train and assist the researcher in good practices of data management and spatial data, once again ensuring the success of the project.

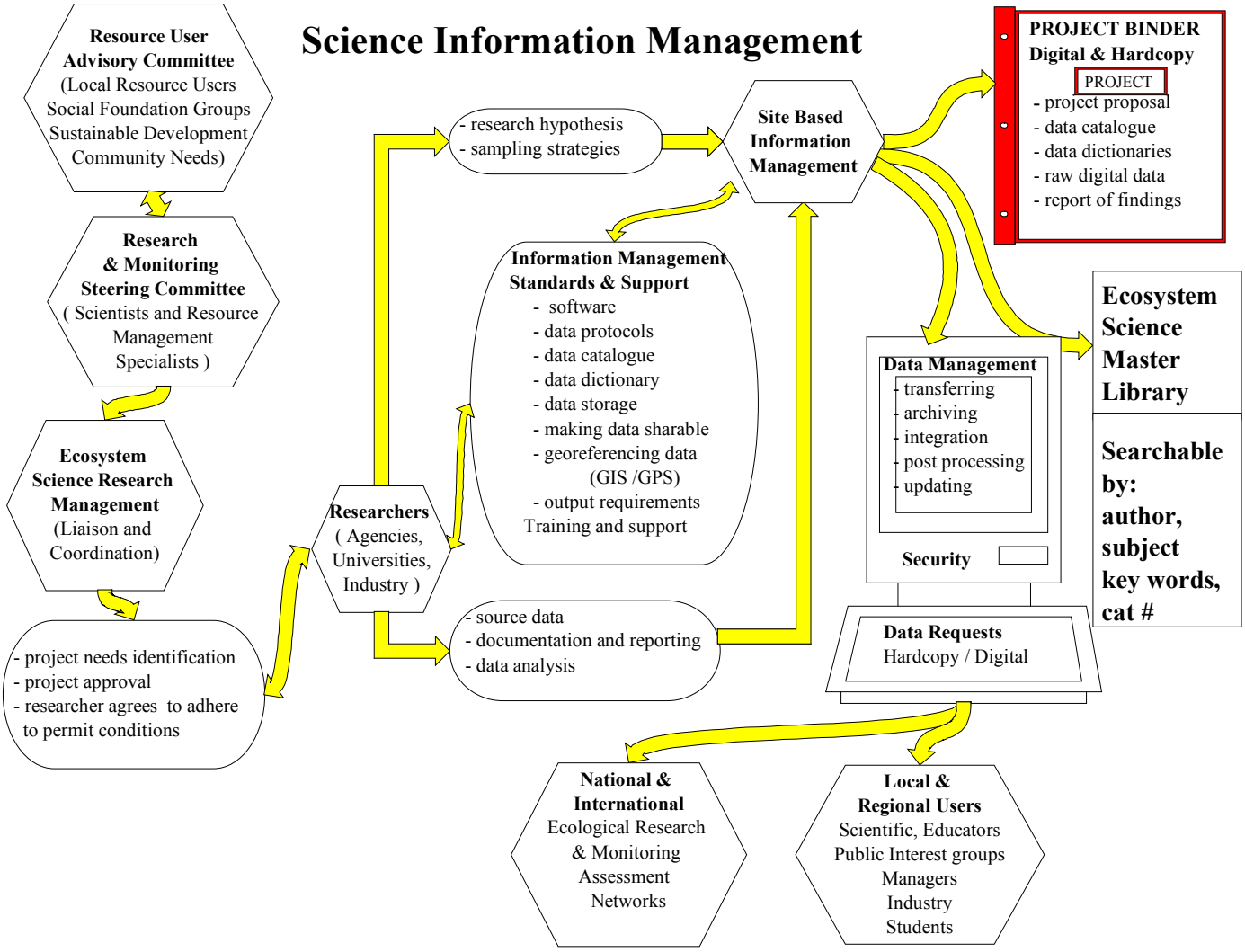

Figure 1. Science Information Management flow chart.

Data Catalogue

The data catalogue contains all of the metadata (information) about the data collected. It is the who, what, where, when, why and how on the data and is the critical document for familiarization and understanding of the project and associated data. The data catalogue is filled out by the researchers and finalized at the project's completion. This catalogue contributes to the creation of a national directory of research projects and data.

Data Dictionary

The data dictionary lists and describes file structure, individual data fields, all codes and includes an abstract, version of software used as well as a log of data set modifications. The data dictionary is

developed by the researcher in consultation with the information management specialist.

Evaluations

A research evaluation system has been set up to ensure projects are being carried out using agreed upon terms of reference and compliance with the above procedures. The rationale for an evaluation is to assist in the success of the project by way of constructive assessment and is confidential. The evaluation process usually includes advisors (university professors) and peers (others doing the same type of research), along with the Kejimkujik Ecosystem Science Manager.

Data Sharing

Data collected must not only be usable, but in the spirit of cooperation, shareable. Data sharing and proprietary rights must be agreed upon. For the KNP Science Information System we have developed a data usage application and agreement contract which facilitates exchange of data sets while defining the proprietary rights and use constraints. The rights to the data can either be held by an outside agency, an individual or solely by the park. If an outside agency or individual holds the rights, we serve as pointers to the owners and location of data rather than distributors the data. If it is Parks' data then it can be distributed as seen fit by the park. The data usage contract also serves as a method of contact to the users if there are any updates or corrections after distribution.

Data Archiving

Documentation and data are stored both on and off site. The data, documentation, and reports and maps are stored in the software of origin, ASCII (where applicable) and hardcopy. As well, the digital files are migrated to newer software versions and media as technology advances. All source data is to be left at the Kejimkujik Ecosystem Science Centre. We recommend researchers do periodic backups of the data throughout the project and leave the backups with the park information manager, as for reasons too numerous to state, the only copy of the data may be the park copy. In many cases, we should be regarded not as distributors of data but rather archivists who assist in the long term accessibility of the data by retaining a copy of the project's data and documentation.

History of BioMon Software

BioMon software was first developed for the SI/MAB Forest Biodiversity Plot Monitoring Programme by the Smithsonian team. As the plots were being established in remote locations, a programme was necessary to have tree listings and maps for on-site verification, Dr. Jim Comiskey developed a portable package.

By 1994, when the first Canadian SI/MAB plot was established in Kejimkujik National Park, the software had gone through a few evolutions, using different compilations of vendor packages. As the proprietary packages (for on site data entry and map production) were too expensive for the local research centres to buy partnerships with the Nova Scotia Centre of Geographic Sciences were established to make the programme more "user-friendly".

Under the direction of Roger Mosher, COGS Programming Instructor, a programme to the identified specs was developed. As it was intended for usage worldwide, it had to adhere to the common denominator at the time; a DOS-based rather than a Windows system. This DOS based BioMon quickly proved archaic to the North American users and the task of programming a Windows-based system was once again undertaken by Roger Mosher.

In adapting the programme to a Windows-based system, the structure also changed to allow for the inclusion of more than just the SI/MAB Forest Monitoring Plots; the programme was developed with the idea that many more monitoring modules could be added to the base system. To date, BioMon has the capability to house the entry and processing of both SI/MAB Forest Monitoring Plot and Modified Whittaker Plot data. As well, there has been a substantial start on forest bird monitoring module but the continuance of this module depends on further interest and development dollars.

BioMon is the software recommended by EMAN to use for data collected in monitoring projects. This programme meets international standards and fulfils Canadian requirements for data compilation. It has been tailored specifically for the cataloguing, archiving and organization of plot data. This software is also able for perform rudimentary statistical analyses and provides detailed interactive maps of the tree positions within plots. BioMon has come a long way from it's first inception and has the potential to satisfy many more monitoring protocols.

Conclusion

In the future we must be able to step back in time and understand a project's results. As well, the data collected now should have the ability to be used by future researchers for purposes not necessarily presently known.

As a system is only as good as its parts, the success of the KNP Science Information Management System and all ecological monitoring programmes relies predominately upon the components of data management

and documentation. Documentation is not only vital to the success of these systems, but is critical to extending the life of the data beyond an initial researcher. It has been suggested that documentation of the processes is as important, if not more so, than the product itself. Remember: documentation is the first piece of information requested when someone investigates the use of research and monitoring protocols or data.

The idea of data management and archiving is essential to the success of long-term projects such as the EMAN forest biodiversity monitoring plots. Those carrying out monitoring programmes must give serious consideration to their own system of documentation and information management in order to allow for data to be used in the future and by the Environmental Monitoring and Assessment Network and it partners.

List of Figures and Tables

Figure 1 Science Information Management flow chart.

CHAPTER 5
CURRENT STATUS OF FOREST MONITORING IN CANADA

The idea of long-term forest biodiversity monitoring in Canada is still in its infancy. Over the past seven years EMAN has built up a monitoring network of plots and protocols for Canadian forest systems. Most plots have only been inventoried once and, in many cases, the data collection has not been completed or the data is not available to EMAN and its partners. However, the establishment of over 90 plots in a seven year period is quite an extraordinary feat, it is important that we should continue to capitalize on this momentum and unite these individual sites under a common national umbrella.

To begin to do this, it is necessary to assess our current status. We need to consider what directions are important within the framework of EMAN, what EMAN CO can realistically do, what aspects of forest biodiversity can help us understand what is changing and why, and how can these results be communicated in a timely and effective manner. By first determining exactly where we are we can begin to tackle the issue of where we would like to go.

A Review of the Current Status of EMAN Forest Monitoring Plots

The distribution of EMAN forest monitoring plots is heavily weighted towards certain areas (see Table 1). The majority of the plots are located in areas of high human populations (Mixedwood Plains, Atlantic Maritime, Boreal Shield and Pacific Maritime). As the initial surveying and continued monitoring of the plots requires significant investments of time, money and work, it seems logical that the majority of plots are located in regions where these criteria are met.

Ecozone	Number of Plots	Ecozone	Number of Plots
Arctic Cordillera	-	Northern Arctic	-
Atlantic Maritime	17	Pacific Maritime	10
Boreal Cordillera	2	Prairies	1
Boreal Plains	2	Southern Arctic	-
Boreal Shield	13	Taiga Cordillera	-
Hudson Plains	2	Taiga Plains	1
Mixedwood Plains	39	Taiga Shield	-
Montane Cordillera	4		

Table 1. Summary of the distribution of known plots across Canada by ecozone. Total of 91 plots.

Of the 91 known EMAN forest monitoring plots in Canada, approximately 40 submitted various types of data summaries and questionnaires to the EMAN CO. From this, we were able to look at how the plots are distributed among various government agencies and organizations. Table 2 shows the number of organizations or representatives involved in plot establishment. However, this is not a clear view of responsible stakeholders as many monitoring programmes are cooperative ventures between many different partners. For example, the Hockley Valley Plot is in a provincial park but was established through a Niagara Escarpment Biosphere monitoring programme.

Plot Location	Number of Agencies / Organizations Involved	Number of plots
Conservation Authority	4	9
Education Centre	12	14
Parks, National	14	24
Parks, Provincial	2	2
Research Station/ University/ Government	14	22
Other (private lands)	3	16
TOTAL	**49**	**87**

Table 2. Summary of plot location and responsible agents across Canada. Plots where responsible authority was not clear are not included in the summary.

National Parks have played a significant role in establishing large numbers of EMAN forest monitoring plots. This may be due to the usefulness of EMAN monitoring plots in the early detection of changes or issues of concern. Plots are also effective tools in meeting objectives of protection, education and awareness in a park's management plan. However, to date less than half of the National Parks have established EMAN forest monitoring plots. Perhaps over the next few years, more EMAN forest monitoring plots can be established to help with efforts to assess the ecological integrity of our National Parks.

Roughly 32 plots have been established in protected areas of varying degrees. As we begin to look at the data accumulated over the past seven years, it is evident that a number of years will have to pass before any information on trends on the state of Canadian natural areas can be noticed. The current system provides us with baseline data on the current status of various forest ecosystems.

The ultimate goal in recording biological diversity is to build a factual foundation for answering basic questions about evolution and ecology (May, 1992). While questions focussing on evolution may not be of the utmost importance on a national or even regional level, ecological questions - response of species to certain stresses (human, climatic) and changes in composition (with respect to introduced species, changes in ranges of tolerance) are more applicable. Therefore, the next logical step is to determine the extent to which the EMAN forest monitoring plots are representative of tree species diversity in Canada. Although this is a very subjective question, Table 3 roughly summarizes how representative the plots are of tree vegetation in each ecozone across the country. Only data from detailed plots in various ecozones were used in this summary, as not all of the plots have data available for evaluation. If we are looking at what is changing and why in terms of biodiversity, we need to make sure we have an accurate representation of what is in Canadian forest ecosystems.

Ecozone	Number of Plots in Ecozone	Number of Species in plots	Number of Species in Ecozones	Species found in plots compared to all species in Ecozone (%)
Taiga Plains	1	2	16	12.5
Boreal Cordillera	2	10	15	66.7
Pacific Maritime	7	23	45	51.1
Boreal Plains	2	6	23	26.1
Prairies	1	5	18	27.8
Boreal Shield	5	19	55	34.5
Mixedwood Plains	17	64	106	60.4
Atlantic Maritime	4	16	57	28.1

Table 3. Number of species accounted for in EMAN forest monitoring plot inventories. Species that are considered to be cultivated and introduced, ambiguous in distribution or nation wide and not recorded in plots were not included. Species which were labelled by group (e.g. Salix sp.) are recorded as being one species. (Adapted from Pilot Analysis of Global Ecosystems, Coastal and Marine Biodiversity, World Resources Institute).

Obviously, tree species that have wider distributions and are numerically more abundant are going to be better accounted for by the EMAN forest monitoring plots, whereas relatively rare species that are found in few numbers in certain ecoregions are likely going to be underrepresented or missed altogether. It is however, interesting to note that in more than half of the ecozones which have plots, less than 50% of the estimated tree species present in those ecozones have been recorded in the EMAN forest monitoring plots. If we evaluate our current data in this way, it would seem that ecozones are not being adequately represented in terms of tree diversity. This shows a need for more plots or plots distributed evenly throughout an ecozone to capture region-specific species. Though there are gaps in monitoring information, perhaps we have enough of a foundation of biodiversity to begin tracking the effects of certain events, changes and impacts on forest biodiversity rather than simply changes in forest composition.

The information summarized in tables 1, 2 and 3 is simply scratching the surface of information that can actually be gathered from the EMAN forest monitoring plots. The vegetative information that is collected is very detailed, but as trees in a forest are slow to respond to change, it is essential to collect additional basic information on biodiversity using complementary, standardized protocols that will potentially provide

more information quickly on the changing state of the environment. This is why EMAN has been undertaking the development and testing of the protocols listed in Chapter 3 (FrogWatch, WormWatch, PlantWatch etc.). This is also why the 20 x 20 metre plot size has been added in order to allow for annual re-evaluation and indicator specific monitoring. Though not all the tools are in place for a complete integrated monitoring network, we are on our way. EMAN we will continue to learn and adapt to monitoring needs and findings.

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SUMMARY OF CASE STUDIES AND ANALYSING AND APPLYING COLLECTED DATA

Case Studies

Forest Biodiversity Plots on Galiano Island

Angela Jean-Louis
Galiano Conservation Association

Galiano Island is home to one of Canada's most limited biogeoclimatic zones: The coastal Douglas-fir ecosystem. Information on protecting the biodiversity of this system is being assessed through the use of SI/MAB protocol for forests as these inventories offer a framework for biodiversity research.

Smithsonian Institution/Man and the Biosphere (SI/MAB) plot use in Kejimkujik: A Brief Discussion

Cliff Drysdale, Ecosystem Science Manager
Kejimkujik National Park

SI/MAB plots were placed in Kejimkujik for training and experiment purposes, evaluating the protocol on its input into long-range air pollutant impact on Acadian forest ecology. Associated protocols for data collection and management have facilitated data comparisons with other commonly used forestry plots in Nova Scotia.

Ontario's Niagara Escarpment (ONE) Monitoring Programme

Anne Marie Braid
ONE Monitoring, Niagara Escarpment Commission

The SI/MAB protocols have been adopted by the ONE monitoring programme to track long-term biodiversity changes along the Niagara Escarpment. Monitoring is carried out by students from the University of Waterloo, providing them with theoretical and practical knowledge of environmental monitoring.

Atmospheric Change and Biodiversity

Don MacIver
Atmospheric Environment Science, Environment Canada

The heat unit by family diversity model for forests, suggested by Rochefort and Woodward (1992), provides a useful global baseline against which to examine and evaluate SI/MAB plots (i.e. expected versus observed), particularly along the Niagara Escarpment in southern Ontario.

Summary of Preliminary Report on Ice Storm Damage

Martin Lechowicz
Department of Biology, McGill University

In January 1998, the area from around Kingston, Ontario east to the Maritime provinces was struck by the worst glaze ice storm of the century. Prior to the ice storm, four permanent forest biodiversity monitoring plots had been established in this region. Quantitative assessment of the damage to all four of the plots was made using SI/MAB and Québec Ministry of Natural Resources protocols.

Long Point Biosphere Reserve

Brian Craig
Network Science Advisor, EMAN
Christine Rikley
Environment and Resource Studies undergraduate, University of Waterloo

The Long Point Biosphere Reserve adopted the SI/MAB protocol as part of a long-term forest biodiversity monitoring initiative. Data collection on vegetation and salamanders has been done by elementary and high school students since 1995. Results produced information on the cause of decreases in Eastern Flowering Dogwood trees.

Centre for Atmospheric Research Experiments
Don MacIver
Atmospheric Environment Science, Environment Canada
Marianne Karsh
Executive Director, Arborvitae

The Centre for Atmospheric Research Experiments (CARE) was established in 1988 and is Canada's national experimental site for testing new atmospheric instrumentation as well as for detecting long-term atmospheric change. Research towers have been located in a SI/MAB plot as the co-location of biodiversity monitoring along with atmospheric monitoring was an important first step between 1988-1994.

Paired Plots
Alice Casselman
Association for Canadian Education Resources

The community-based monitoring programme was built on the premise that laypersons could become accurate data gatherers of forest biodiversity information. Pairs of plots have been established, one for demonstration and training, while the other is for use by researchers.

SI/MAB in the Yukon or How to Measure Lots of Little Spruce Trees on Hills
Joan Eamer
Environment Canada, Yukon

Applying a methodology designed for tropical rain forests to northern coniferous forests poses some interesting challenges. Listed in this article are the accommodations that were made to adapt the SI/MAB methodology to these conditions.

Bioregional Mapping on Toronto Island's Biodiversity Plot
Marianne Karsh
Executive Director, Arborvitae

Bioregional maps are community-based and communicate a story both in images and in words. Once a bioregional map is complete, it becomes the foundation of knowledge from which planning scenarios can be prepared.

Analysing and Applying Collected Data

The Biodiversity Issue
Don MacIver
Atmospheric Environment Science, Environment Canada
A summary of the two key documents, The Canadian Biodiversity Strategy and The Science Assessment on Biodiversity, which served to ratify Canada's commitment to the Convention on Biological Diversity.

Biodiversity Framework
Don MacIver
Atmospheric Environment Science, Environment Canada
One possible means of conceptualising and framing the various goals and uses of the EMAN forest plots.

National Comparisons

Marianne Karsh
Executive Director, Arborvitae

This article presents one possible method of analysing data generated by the EMAN forest plots. Data and information collected from 40 plots are summarized and used to generate diversity curves, a technique which gives greater weight to more abundant species, for various areas across Canada and around the world.

The following contains various partner submissions, reports and case studies as originally received and upon which this report was based.

CASE STUDIES

Forest Biodiversity Plots on Galiano Island

Angela Jean-Louis

Through community-based land trusts, monitoring plots have been set up on Galiano Island. The loss of biodiversity has become an area of concern as the island is home to important ecosystems. The SI/MAB protocols for ecological monitoring plots are in use by the Galiano Conservancy Association as a framework for biodiversity research.

Galiano Island encompasses some 6,000 hectares of coastal Douglas-fir ecosystem which is one of Canada's most limited biogeoclimatic zones. This zone is also one of the most vulnerable zones to population encroachment. It lies at the edge of Canada's third largest metropolis (Greater Vancouver) in a narrow band around the Strait of Georgia, through an area of rapid coastal development along Vancouver Island's eastern shore and at the foot of the Coastal Range of British Columbia. Less than two per cent of the coastal Douglas-fir zone is protected and almost none remains unaltered by resource extraction and settlement that began only one hundred and fifty years ago.

The Galiano community has long valued the beauty and fragility of its landscape. Setting aside conservation areas has been a tradition for many years. Now over fourteen percent of the island lies in parks and reserves that all have a conservation objective in common. The Galiano Conservancy Association began a decade ago as one of Canada's first community-based land trusts. It has secured land in protected status through outright purchase, partnerships, co-management and conservation covenants. These projects have succeeded through cooperation with local, regional, provincial, federal governments, industry, national and provincial Non-Governmental Organizations (NGOs), nearby universities, and members and supporters of the Galiano Conservancy.

The establishment of protected areas is only one conservation strategy for the Galiano Conservancy. Many public education projects focus on conservation awareness in the community, since most of the island lies in private ownership, surrounding the designated conservation reserves. No matter how successful we are at promoting conservation, the responsibilities of land stewardship require that we confront our understanding of how well this conservation is, in fact, protecting biodiversity. The Smithsonian Institution / Monitoring and Assessment for Biodiversity (SI/MAB) protocol for forest inventories offers a framework for biodiversity research.

Galiano Island

In 1996, the Galiano Conservancy established a conservation agreement between key provincial and federal agencies, and NGOs to protect and designate the Pebble Beach Reserve. Conservation values for the 322-acre Reserve include management objectives for monitoring the natural composition and function of the

coastal Douglas-fir and associated ecosystems. To pursue this possibility, in 1995 and 1999, the Galiano Conservancy gained formal training to follow the international SI/MAB forest inventory protocols.

Being home to an array of forest types, the Pebble Beach Reserve stands out as an unparalleled site for biodiversity studies. The area consists of a rare remnant of old-growth, a naturally regenerated second growth and a healthy young Douglas-fir plantation. This unique area offers an opportunity to implement comparison studies and monitor contrasting biodiversity among these different stands on adjacent permanent plots.

In 1999, our initial SI/MAB project established the first monitoring plot in the Reserve and conducted an initial baseline tree inventory. In order to extend the knowledge base of these local systems, additional inventories will be conducted here on various ecosystem components in the future. The summer of 2001 will see two additional plots added. Subsequent inventories, slated for the future, will include shrub layer species, mosses and lichens, fungi, invertebrates, birds, mammals and amphibians. Analysis of even the most rudimentary data collected over time will record baseline biodiversity characteristics never available before and evidence of the ecosystem's dynamics.

Better understanding of the way complex natural systems function can contribute to more effective land stewardship on Galiano Island and elsewhere in the coastal Douglas-fir zone. Raising public awareness about the consequences of disrupting ecological relationships and about the rehabilitation of natural system functioning may begin to slow biodiversity loss.

In focusing on education and research, the Galiano Conservancy Association's biodiversity monitoring programme not only upholds its conservation objectives but also contributes to raising provincial appreciation that a priority on appropriate land use planning and management is the only safety net for this rare and threatened ecosystem.

Smithsonian Institution/Man and the Biosphere (SI/MAB) plot use in Kejimkujik: A Brief Discussion

Cliff Drysdale

Smithsonian/MAB Plot Application in Kejimkujik

Use of SI/MAB Forest Biodiversity Monitoring plots in Kejimkujik National Park and National Historic Site began as both a training exercise and an experiment to evaluate the SI/MAB plot protocol for monitoring the impact of long range transport of air pollutants on Nova Scotia Acadian forest ecology. The 1 hectare SI/MAB plot, with its twenty five 20 x 20 metre quadrats, also appeared to be large enough to explore opportunities for site-based relational analysis of data sets resulting from multi-disciplinary biodiversity and ecological process studies. The SI/MAB plot configuration, and associated protocols for data collection and management, have facilitated data comparisons with other commonly used forestry plots in Nova Scotia.

The first two SI/MAB plots were installed in Kejimkujik in April 1994. Site selection was limited because snow remained on much of the forest floor and access to a variety of forest types was restricted. Plot 1 was installed in a mixed hardwood stand, while Plot 2 was placed in a mixed softwood stand. Both sites were representative of typical park forests and the plots were intended to serve as a basis for subsequent studies at the landscape scale. Participants in the plot installation exercise came from a variety of government agencies, academic institutions and industry.

As a consequence of the creation of these first two plots, significant interest was generated in multi-disciplinary, plot-based monitoring from two perspectives.

First, a variety of research agencies and educational institutions recognized the opportunity to carry out site assessments for a variety of abiotic and biological components at the plot sites: forest microclimate, soil chemistry, basidiomycete and decay fungi, lichens, micro-invertebrates, forest canopy lepidoptera and forest bird sampling studies have since been initiated. In some cases longer term monitoring and replicate sampling has been implemented.

Cliff Drysdale instructing a training session.

Second, representatives of the forest industry expressed interest in having SI/MAB plots installed on their land to help evaluate harvest and sylviculture techniques. This led to the installation, by student employees and adult trainees, of three more SI/MAB plots and replicate quadrats outside park boundaries on commercial forest lands of Bowaters-Mersey Paper Company, N.F. Douglas Lumber Company and Harry Freeman and Son Lumber Company Limited. The installation of these plots led to co-operative efforts in establishing control sites inside the National Park, monitoring forest birds, monitoring ground vegetation and studying tree regeneration associated with plot locations on working landscapes. More recently, an SI/MAB plot has been installed at Thomas Raddall Provincial Park on the Atlantic Coast. The first plots are now being remeasured to determine tree recruitment, growth and mortality.

Concurrently Kejimkujik staff, faculty from the Nova Scotia Centre of Geographic Science, and the Smithsonian Institution have collaborated in further development of BioMon software, which supports data management requirements for the SI/MAB plot based monitoring.

Results

The remeasurement results of forest tree species within Kejimkujik SI/MAB Plots 1 and 2 have yet to be fully analysed following resampling in 1999. The early spring installation in 1994, before leaf-out, made initial discrimination of dead versus live trees subject to error, although this has subsequently been corrected. Similarly, use of two different dbh measurement tools (tapes and tree calipers) may have initially resulted in reduced accuracy and re-measurement became necessary. The original SI/MAB protocol did not require the measurement of dead standing trees; this process was adopted with initial Kejimkujik plot installation. It is expected that the ongoing monitoring and re-assessment of these plots will benefit from the experience gained during the first monitoring cycle.

The results from the variety of associated plot studies carried out on the substrate and on a variety of biotic elements in Plots 1 and 2 have provided a significant amount of valuable information.

- Soil chemistry analysis determined that calcium values at the sites were among the lowest in North America, further substantiating concern about sustainable acid deposition levels and the potential impact to sustainable forestry on working landscapes.
- A number of fungus species new to Nova Scotia were identified.

- Studies of forest soil invertebrates examined the collembola, mites, soil mollusca and myriapoda. Among a variety of findings, it was determined that the majority of myriapoda found at the study sites were exotic species.
- The forest canopy lepidoptera monitoring at the site of Plot 1 identified new species for Nova Scotia, including a hybrid of pine and spruce budworm.
- The first records of gypsy moth for inland Nova Scotia were made at Plot 1.
- A variety of acid sensitive lichens and basidiomycete fungi were also identified on the plots.
- While the forest bird monitoring study carried out in association with the plots has yet to be completed, preliminary results of comparison with the plots in harvested areas outside the park (N.F. Douglas Lumber Company and Bowaters Mersey Paper Company plots), with controls in Kejimkujik, have proven to be extremely informative with respect to bird biodiversity and territoriality in managed forests versus natural areas .

Bug bucket from Lepidopteran inventory.

The use of SI/MAB plots on Bowaters Mersey Paper Company commercial forest land has been augmented with a variety of other sampling techniques to evaluate changes in ground vegetation including red spruce regeneration. This project is on-going and has received additional funding from the National Science and Engineering Research Council (NSERC) fund.

Maintenance of the microclimate tower installed adjacent to Plot 1 has been quite problematical because of logistical concerns and some technical difficulties. Data from this installation has been sparse to date.

The revision to the Biomon software as carried out by Nova Scotia's Centre of Geographic Sciences and Kejimkujik staff has proven to be very effective. The current software appears to be very flexible and robust.

Conclusions

The long-term nature of plot based monitoring precludes a definitive analysis of results from the sampling activity at Kejimkujik, however it is possible to draw some general conclusions about the use of SI/MAB plots.

- The full one hectare SI/MAB plot should be considered as one of a variety of measuring and monitoring tools. Its use should be based on its relevance in context with the research and monitoring objectives identified prior to plot site selection. The utility of the 20 x 20 metre plot should also be considered, depending on the application required. The SI/MAB quadrat is supported by the same software, but does not require the same time investment to install. This is an important consideration of multiple plot replicates and controls are required.

- Care should be taken to ensure sufficient replication and controls are developed if results are to be extrapolated to a larger geographic area. The new BioMon software is also flexible enough to allow configuration of quadrats to comply with site characteristics.

- Careful attention to the standardized measurement protocols is essential, particularly if installation teams change from year to year. Even professionals can be tempted to depart from use of standard protocols, to the detriment of quality results. Vigilance is essential.

- The SI/MAB plot appears to be an excellent tool for educational purposes, which can simultaneously address monitoring needs. Kejimkujik has used students extensively for plot installation. Their results appear to be at least as accurate as those of adults in this endeavour. Students have repeatedly commented that their participation has been an important learning and team building experience.

- Use of SI/MAB plot based monitoring, as part of a partnership with other land users, offers an excellent opportunity to advance cooperation and dialogue among parties who may not normally collaborate.

Ontario's Niagara Escarpment (ONE) Monitoring Programme

Anne Marie Braid

The Ontario Niagara Escarpment (ONE) programme, using SI/MAB protocols, has been established to track long-term biodiversity changes along the Niagara Escarpment. As part of a block field course, students from the University of Waterloo are responsible for collecting information within the plots which provides them with theoretical and practical knowledge of environmental monitoring.

Monitoring Forest Biodiversity as part of the Ontario's Niagara Escarpment (ONE) Monitoring Programme

The Niagara Escarpment Plan, Canada's first large-scale environmental land use plan, came into effect in 1985. The Plan implements the Niagara Escarpment Planning and Development Act, the purpose of which is "to provide for the maintenance of the Niagara Escarpment and lands in its vicinity as a continuous natural environment, and to ensure only such development occurs as is compatible with that natural environment".

The Niagara Escarpment Plan establishes land use policies along the Escarpment that work towards: (1) protecting and enhancing unique ecologic and historic areas; (2) maintaining and enhancing water resources; (3) providing opportunities for outdoor recreation; (4) maintaining and enhancing open landscape character; (5) providing public access; and (6) ensuring all land use is compatible with the purpose of the Act.

Inventorying ground vegetation at Skinner's Bluff.

Ontario's Niagara Escarpment (ONE) Monitoring Programme is a long-term monitoring strategy to assess whether the policies of the Niagara Escarpment Plan are adequate to achieve the purpose of the Act. It is designed to monitor the linkage between land use change and ecosystem status and to examine the cumulative environmental effects of development. The objectives of the ONE Monitoring Programme are taken directly from the Act. These objectives address: terrestrial ecology, water, recreation, open landscape character, public access and land use. The objectives are translated into questions which the monitoring programme can answer.

As part of the terrestrial ecology objective of the ONE Monitoring Programme, Smithsonian Institute Man and Biosphere (SI/MAB) protocols were adopted to track long-term changes in forest biodiversity in permanent plots along the Escarpment. Relatively undisturbed or "control" plots are located in areas along the Escarpment that have the highest level of protection. Control sites will eventually be compared with disturbed or "pressure" sites to achieve a greater understanding of the effects of development on the natural environment. Sites are selected based on a number of criteria, which are:

Measuring dbh at Cabot Head.

- for control sites, lack of human pressure and high ecological health of the area;
- for pressure sites, proximity to a recent or planned (within the next two years) major stress;
- proximity of existing monitoring programmes or other past data collection;
- suitability / likelihood of the site for the establishment of other monitoring programmes;
- co-location of component types (i.e. forest, wetland, old field);
- likely presence of "indicator" (rare or significant) species;
- proximity of a compatible control or pressure site; and
- long-term security of the site and approval by the regulating agency.

SI/MAB plots also provide the opportunity for additional research activities, such as monitoring tree health and ground vegetation. Students who collect the data are provided with an educational experience. The data collected in the plots can build on the information gathered through other programmes, such as the Forest Bird Monitoring Programme of the Canadian Wildlife Service.

University of Waterloo Environmental Monitoring Course as a model for SI/MAB plot establishment

Since 1996, second-year University of Waterloo students have been collecting forest biodiversity data in Smithsonian Institute Man and Biosphere (SI/MAB) plots along the Niagara Escarpment as part of a block field course in Environmental Monitoring. The course is held through a partnership between the Ontario's Niagara Escarpment (ONE) Monitoring Programme of the Niagara Escarpment Commission, the Ecological Monitoring and Assessment Network, the Ministry of the Environment and the University of Waterloo. To date, students have established plots at the Hilton Falls Conservation Area, Hockley Valley Nature Reserve, Cabot Head Nature Reserve, Hope Bay Nature Reserve and Skinner's Bluff Management Area.

The course is designed to provide students with theoretical and practical knowledge of environmental monitoring in the context of the Niagara Escarpment Biosphere Reserve. It is scheduled during the last two weeks of August. Students stay at group camping facilities for the duration of the course. Generally, the course consists of three main components:

1. Instructors and a variety of guest speakers provide an overview of the Niagara Escarpment Commission, the ONE Monitoring Programme, the international Man and Biosphere Programme, biosphere reserves and Escarpment monitoring activities.

2. A field component provides students with "hands-on" experience in implementing an international protocol. Teamwork is an important part of this component.

3. Students are involved in data entry using BioMon and are responsible for field checks to verify the collected information.

In addition to the SI/MAB protocol, students are also exposed to other monitoring techniques, such as tree health, shrub/sapling layer and herbaceous layer monitoring.

The University of Waterloo Environmental Monitoring course is an excellent way to create an educational experience for students and at the same time a means of collecting data that the ONE Monitoring Programme can analyse for long-term changes in forest biodiversity.

Atmospheric Change and Biodiversity

Don MacIver

As changes in biodiversity have now been linked to changes in atmosphere, forest biodiversity monitoring plots can provide baseline data on atmospheric related variation in ecosystems. SI/MAB plots can be evaluated based on a heat unit from family diversity models which identify whether biodiversity within plots correspond with the expected biodiversity of the current climate.

The atmosphere is dynamic, changing and extreme. The atmosphere influences processes at all levels of biodiversity and their many interrelated populations. It is difficult to think of a biodiversity process that is not directly or indirectly adapting to a changing atmosphere. Many components of biodiversity are naturally adapted to a certain degree of atmospheric variability (i.e. climate variability) and will migrate or go extinct depending upon the rates of atmospheric change (i.e. climate change).

Heat is a powerful trigger. Changes of 1 or 2 degrees centigrade translate into significant biological impacts, adaptations and vulnerabilities. The heat unit by family diversity model for forests, suggested by Rochefort and Woodward (1992), provides a useful global baseline against which to examine and evaluate SI/MAB plots (i.e. expected versus observed). The heat unit is the accumulation of heat above the base temperature of 5C commonly referred to as growing degree days (GDD). In addition, this basic relationship, illustrated in Figure 1, served as an effective diagnostic tool to identify plots where the biodiversity was or was not in equilibrium with the present climate.

Further, this baseline relationship also served as an essential transfer function when merged with the long-term bioclimate maps for Ontario (Watson and MacIver, 1995). The spatial variability of climate-based biodiversity was mapped and then subjected to a $2xCO_2$ atmosphere, using climate change scenarios to calibrate and again map, the anticipated and future changes in biodiversity (MacIver, 1998). This mapping technique also helped to identify areas in southern Ontario that will require enhanced conservation practices for the adaptability of native species, including areas that will be vulnerable to invasive exotic species which will serve as critical early-warning sites for detecting the presence of invasive exotic species.

The SI/MAB plots provided initial verification of the family diversity baseline nationally, but more importantly, allowed for the construction and calibration of the biodiversity baseline for mixedwood forest species due to the abundance of the SI/MAB plots located across ecological, climate and chemical gradients in southern Ontario. Figure 2 depicts this gradient analysis approach and the relative linearity of the basic heat by family biodiversity relationship for mixedwood forest sites from Long Point on Lake Erie to Tiffin on Georgian Bay (MacIver, 1999).

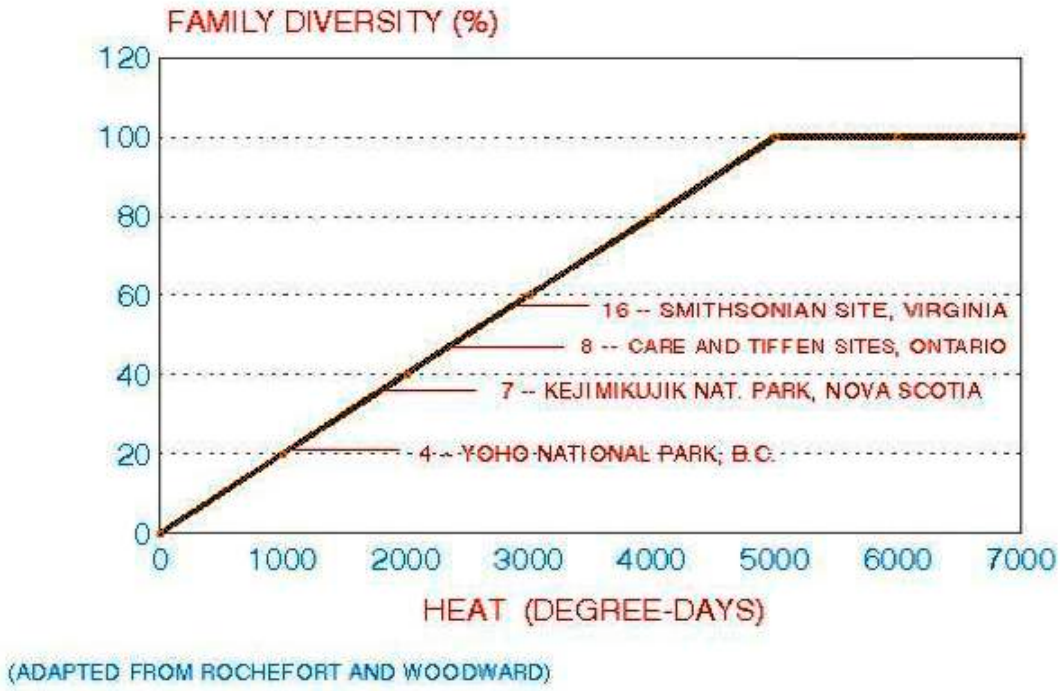


Figure 1. Basic heat by Family biodiversity (forest) baseline plus SI/MAB sites.

In addition to climate variability and change, there are many atmospheric processes that directly affect the structure and functioning of ecosystems and hence, the changing state of biodiversity. These include weather extremes, increased UV-B; acid deposition; increased levels of ground-level ozone and other photochemical pollutants; and suspended particulate matter and hazardous air pollutants.

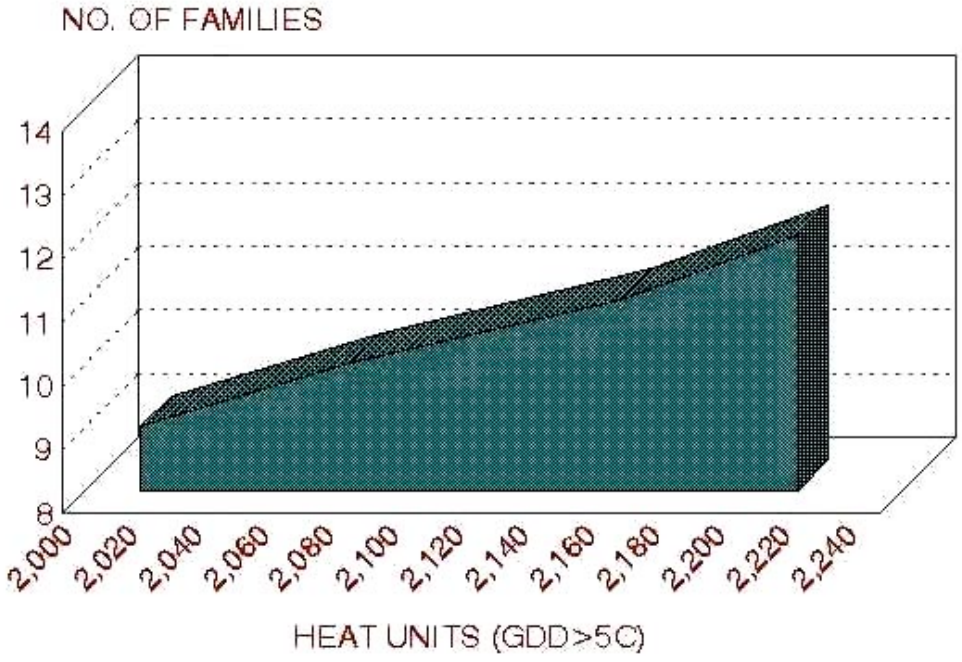
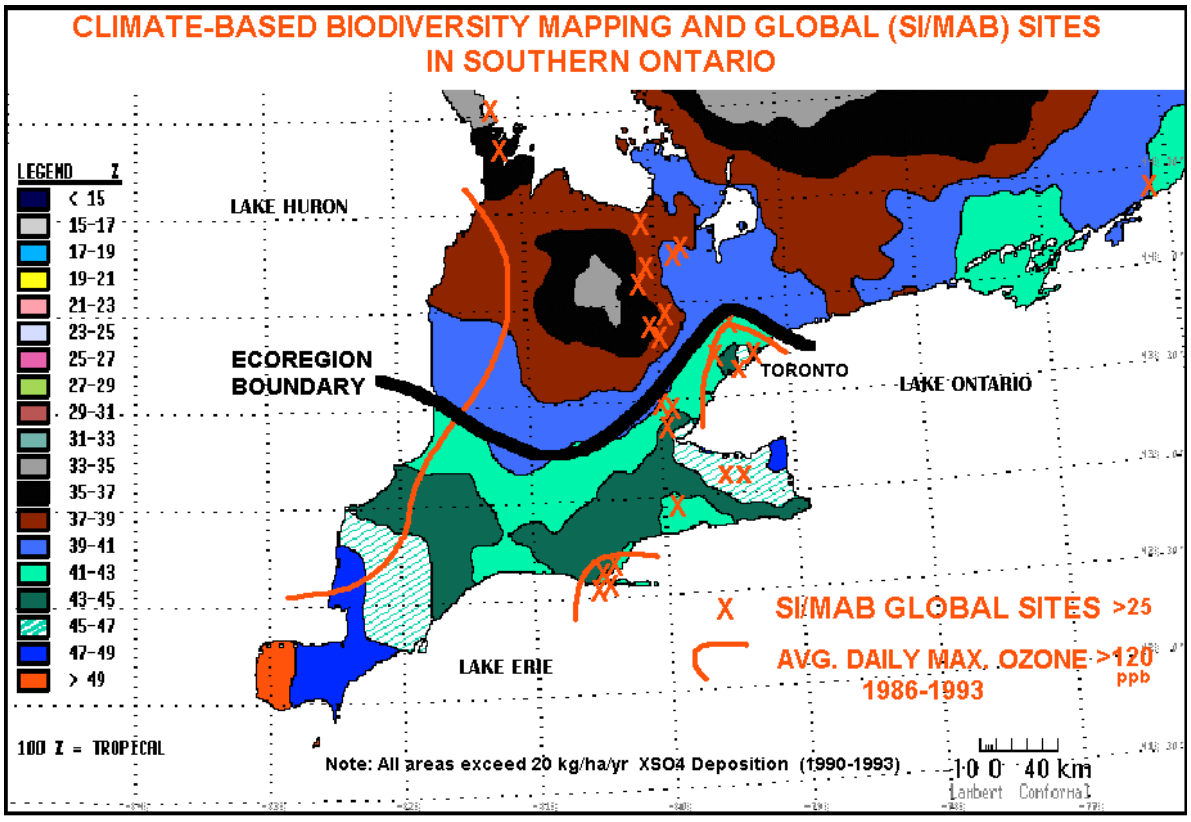


Figure 2. Heat by Family biodiversity for mixedwood forests in southern Ontario, based on SI/MAB plot observations.

Many existing biological and atmospheric monitoring systems collect systematic observations using inventory-type protocols and schedules to record, archive and detect changes. Few abiotic and biotic observations have been collected over the long-term at the same site. Even fewer databases, such as climate, have the universality to provide the connecting spatial linkages with site-based biological observations. However, the geo-referencing of these data observations allows for the spatial mapping and overlaying of different thematic surfaces which, in turn, led to the development of an Integrated Mapping Assessment Project (IMAP). Initiated in 1999, IMAP is on the web at http://www.utoronto.ca/imap/start.htm (MacIver et al. 1999).

For example, if the cumulative impacts of the chemical atmosphere are layered onto the climate-based biodiversity map for southern Ontario (Figure 3 - Legend % refers to percentage of tropical biodiversity as described by Rochefort and Woodward), along with the location of some of the SI/MAB plots, it becomes apparent that human intervention and management is needed to reduce cumulative atmospheric stressors, to rehabilitate and adapt native biodiversity and to reduce the potential for invasion of native vegetation by exotic species (MacIver, 2000).
To further illustrate this conservation challenge, Long Point on Lake Erie, an international biosphere reserve with some of the greatest biodiversity in southern Ontario, is subject to the highest loading of ground-level ozone, high UV-B (latitude), exceedences of acid deposition targets, increasing heating and future global warming, and is surrounded by a highly altered agricultural landscape. The advantage of undertaking climate-based studies in the forest monitoring plots located in the Long Point Biosphere Reserve helps us to obtain quick and relevant information on the changing state of biodiversity.

The SI/MAB plots, using global protocols, perform many integrating tasks and have proven useful in identifying the effects of atmospheric variability and change. It is recommended that more SI/MAB plots



Sources: Atmospheric Change and Biodiversity (Maciver, 1997); 1997 Canadian Acid Precipitation Assessment and the 1980-1993 Ground-Level Ozone and Its Precursors (Data) Assessment (1997), Environment Canada and Science Program

Figure 3. Cumulative impact of the chemical atmosphere; climate-based biodiversity and SI/MAB observation sites.

be established across ecological, chemical and climate gradients in highly altered landscapes in Canada to detect change and adaptation responses.

Canada can ill-afford to lose even one native species or ecosystem compared to the relative richness of more southerly countries.

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Figure 2. Heat by Family biodiversity for mixedwood forests in southern Ontario, based on SI/MAB plot observations.
Figure 3. Cumulative impact of the chemical atmosphere; climate-based biodiversity and SI/MAB observation sites.

Summary of Preliminary Report on Ice Storm Damage

Martin Lechowicz

Four permanent SI/MAB monitoring plots had been set up in Eastern Canada prior to a damaging ice storm that occurred in the winter of 1998. Evaluation of these plots after the storm has allowed for the assessment of damages to the natural environment and has also given baseline data that can now be used to pursue research on ecological recovery.

Summer 1999, Mont St. Hilaire.

In January 1998, the area from around Kingston, Ontario east to the Maritime provinces was struck by the worst glaze ice storm of the century. The most heavily hit regions centred on St-Jean-sur-Richelieu to the south-east of Montr ∂al, Qu∂bec. The Mont St. Hilaire Biosphere Reserve lies within this zone of greatest damage and the old-growth forests in the reserve were

indeed devastated by the storm. The impact of the storm was concentrated in the valley of the St. Lawrence River.

Prior to the ice storm, four permanent forest biodiversity monitoring plots had been established in this region: 1) two sites at the Mont St. Hilaire Biosphere Reserve, Quϑbec, 2) a site at Gananoque, Ontario and 3) a site at Ste-Hippolyte, Quϑbec. SI/MAB protocols were used to collect data on the forest composition and structure at the four sites. Quantitative assessment of the damage to all four of the 1-ha plots was made. As the Mont St. Hilaire Biosphere lay within the zone of greatest damage, a more global estimate of damage within the forests of the Mont St. Hilaire Biosphere Reserve was made by sampling 117 circular quadrats (6-m radius) placed randomly over the entire mountain. Trees were scored for damage using a scale employed by the Quϑbec Ministry of Natural Resources in their province-wide estimates of the effect of the ice storm.

The forests at the Ste-Hippolyte and Gananoque SI/MAB plots were younger and differed in composition than the two plots at the Mont St. Hilaire Biosphere Reserve. Any differences in damage by the ice storm at the sites was therefore reflected in the combined influence of regional and local variation in the intensity of the storm and in the differences in the vulnerability of different tree species to ice damage.

In terms of the damage to individual trees, most of the common canopy species were, on average, equally damaged at a given site. The damage caused to the trees by the ice storm was ranked on a scale of 1 (not or almost not affected) to 5 (severely affected to fatal). The majority fell between "25-50% loss of canopy branches" and "more than 50% branch loss but less than total loss of canopy form". This was an indication that many trees were very badly damaged and subsequently may not be able to recover from the storm. There is little quantitative data in the literature, but indications are that canopy damage, in excess of 50%, will lead to the death of many species. It will be interesting to track individual stems in these plots over the next five to ten years to establish reliable data on the fate of stems and species with different amounts of branch loss.

Down wood

In terms of the forest as a whole, it was clear walking around the Mont St. Hilaire Biosphere Reserve, in the summer after the storm, that almost all sectors had drastically less shade at ground level than in previous years. There was an immense amount of down wood on the forest floor, a tangle of branches through which it was almost impossible to walk. Sugar maple, which was the most abundant tree at the site, also comprised the largest part of the down biomass, but red oak and beech contributed nearly as much debris. These three species accounted for over 90% of the down biomass on the mountain as a whole.

In the past, damage caused by ice storms was documented, but rarely followed up with recovery research. By studying the long term effects on the mortality and recovery rates of the trees in these plots, information that may be useful in predicting mortality and recovery rates, and possible outcomes of future drastic

weather events (particularly if predictions that climate change will bring increased risk of extreme storm events are true) will be gathered.

Long Point Biosphere Reserve

Brian Craig

The Long Point World Biosphere Reserve adopted the SI/MAB protocol as part of a long-term monitoring initiative in order to;

- to monitor and compare forest change in protected areas versus the working landscape;
- to provide a quality learning experience for students by engaging them in data collection efforts;
- to raise the profile Backus Woods, one of the best examples of Carolinian forest remaining in Canada, as an international network monitoring site; and
- to contribute data to the international biosphere reserve monitoring network.

Since 1995, four one-hectare monitoring plots have been established: two in Carolinian forest (Backus Woods and Wilson Tract) and two in Oak-Savannah forest (Turkey Point Plots 1 and 2). The re-inventory of Backus Woods in 2000 revealed an alarming trend in the number of dead standing *Cornus florida* – Eastern Flowing Dogwood, a species which reaches the limit of its northern distribution in southern Ontario – which increased from 15% to 46% over a five year period (Figure 1). Samples were analysed by the Canadian Forest Service and the cause has been attributed to *Discula destructiva* (Dogwood anthracnose), a fungus believed to be recently introduced in Canada, possibly on nursery stock from Asia (Britton, 1994). Left unchecked, Dogwood anthracnose has the capability to destroy most of the eastern flowering dogwood in Ontario within the next five to ten years (Frontline Express, Canadian Forest Service, 2001).

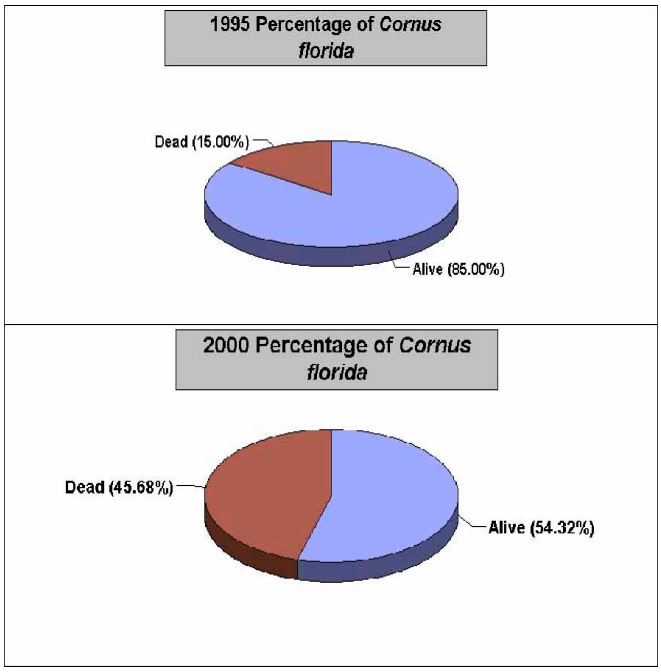

Figure 1. Percentage of alive and dead Cornus florida, Backus Woods, in (a) 1995 and (b) 2000.

A 30 metre climate tower was erected in a closed canopy mature Carolinian forest in 1996, adjacent to the Wilson Tract plot. The station was installed as part of an EMAN initiative to collect climate data with the intent to relate that information (where applicable) to changes in forest composition. Utilising a Campbell Scientific data logger hourly air temperatures at 3, 7, 11, 15, 25 and 30 metres, soil temperatures in the humus and at a depth of 5, 10, 25, 50, and 100 centimetres; and photosynthetic radiation has been collected continuously. Interestingly, the soil in the plot has not frozen over the past four years. Whether this is a recently developed "trend" or this is something that has been occurring for a number of years remains to be seen. It will be very important to maintain the climate station in order to continue to monitor this situation.

A salamander cover board survey at Backus Woods and Wilson Tract was initiated in 1997. Salamander abundance data has been collected on a weekly basis from March to November, 1998-2001. These data are currently being analysed to determine:

- if different types of boards influence the number of salamanders found,
- how many weeks of the year the boards should be surveyed for effective sampling and

- what is the optimal number of boards needed per plot to effectively monitor Plethodontid salamander population trends (over the long-term).

The results of this analysis will serve as the basis for the development of salamander monitoring protocols for eastern Canada. It is hoped that over the next couple of years, these results will also contribute toward the development of salamander monitoring protocols in western Canada.

Engaging students in the collection of tree inventory data from several of the plots has proven to be very successful. In 1995, fifteen grade 8 students were selected to participate in a five day monitoring camp. The students received rudimentary training in tree identification and tagging, tree mapping, and data entry using the BioMon programme. While undergraduate summer student employees, during all tree identification and tagging, supervised the elementary students, the elementary students accurately mapped all of the quadrats without supervision. The data collected by the elementary students was subjected to an audit by Environment Canada and was found to be reliable. It has been our experience at the Long Point Biosphere Reserve that when provided with the proper training and support, elementary school-aged student volunteers are a competent and cost effective means of collecting basic inventory data.

Since the inception of the annual camp in 1995, many students have continued to participate. Of these participants, twelve students were asked to generate a list of reasons, in their own words, for participating in the monitoring camp. Each student then ranked their top three choices from the group list of 28 reasons. Based on this ranking, the following reasons for participating in the camp were obtained.

Top 10 Student Reasons for participating in Long Point summer monitoring camp

1. Doing something for the environment.
2. Fun being with your friends.
3. Leadership has high expectations.
4. Like being outdoors.
5. Unique opportunity.
6. Efficient way to learn.
7. Meeting and working with new peers.
8. Challenging.
9. Fun to do something different.
10. Working with professionals.

It is significant that the second most important reason for participating in the camp was “Fun being with your friends”. Of paramount importance to a successful student monitoring camp are planned recreational activities that contribute to building a strong team and individual self-esteem.

A Student’s Perspective at Long Point

Christine Rickley

Christine working hard.

During the summer of 1995, Brian Craig who was a local teacher at the time, approached me to see if I would be interested in participating in a week-long camp where I, and other students my age, would be collecting scientific data in a nearby conservation area. As I was thirteen years old, I took this proposition as the perfect opportunity to go camping and to have fun with other students from my school. Now, after over five years of being involved in the camp, I have realised that it has provided me with a lot more than just friends and good times.

By becoming involved in that first year, the experience has completely changed my attitude and outlook on the environment, and the work being done to conserve and manage it in a sustainable matter. I, and many of the other students involved throughout the years, have developed a respect for the importance of monitoring changes occurring in our world and identifying what the possible causes are for these changes.

The camp gave us the opportunity to learn science in a hands-on environment; we learned different sampling techniques and what types of indicators can be used to conduct such studies.

By participating in fieldwork with scientists from our area, as well as across Canada, I developed an understanding of why so many have become so dedicated and loyal to their particular interest within the environmental field; why it is important for people like me to follow in their footsteps. This aspect, as well as my love for the environment that has developed and grown over the past years in the monitoring camp, is what has driven me to pursue a degree in Environment and Resource Studies. Without the experiences that I had attained through this project, I am sure my life would have never steered itself in its current direction .

For those students who may not pursue careers in the environmental field, I am sure they too will carry the same love and respect for the environment throughout their lives.

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Centre for Atmospheric Research Experiments

Don MacIver & Marianne Karsh

The Centre for Atmospheric Research Experiments (CARE) was established in 1988 and is Canada's national experimental site for testing new atmospheric instrumentation as well as for detecting long-term atmospheric change. Instrumented towers for temperature, humidity, wind and radiation were established to monitor the horizontal and vertical profiles of heat, moisture and wind. Towers were located in standard open site locations, openings in the forest, forest edges and closed forest environments. The latter two towers were located in the planted red pine SI/MAB plot; a second paired plot was established in the unmanaged mixed hardwood forest. The co-location of biodiversity monitoring along with atmospheric monitoring was an important first step between 1988-1994.

The Growth and Ageing of Forest Biodiversity

Increment cores are part of the recommended international Smithsonian Institution (SI/MAB) vegetation monitoring protocols. The technique of coring trees in order to examine the annual growth rings allows us to accurately determine a tree's age. From the increment core of a Red Pine *(Pinus resinosa)* in the first biodiversity plot at CARE, we can determine that this tree was planted in 1937. There was a rapid increase in average ring width at dbh from 1 cm to approximately 8.5 cm in 1941. Ring widths decreased rapidly after that point, reaching stagnant growth levels of approximately 1 cm average width by 1949. Further decreases in ring widths continued past the year of sampling in 1988 to the present. This tree shows that it was heavily impacted quite early in life and may be showing the detrimental effects of overly close spacing and lack of thinning, thereby providing an overstory nurse crop for increasing hardwood biodiversity in the understory. Growth responses to a management intervention would have been expected since pines respond to natural mortality in the stand (species-spacing) with consequent increases in light and growing space even in later life stages (Karsh, unpublished M.Sc.F. Thesis, University of Toronto, 1992).

Tree Ring Analysis can also be used to enhance research findings on biodiversity plots. Radial measurements of average ring width on cross-sections sampled along a tree stem (every 50 cm or less) result in a curve representing the growth layer profile. These curves are produced by the Tree Ring Increment System (Fayle and MacIver, 1986).

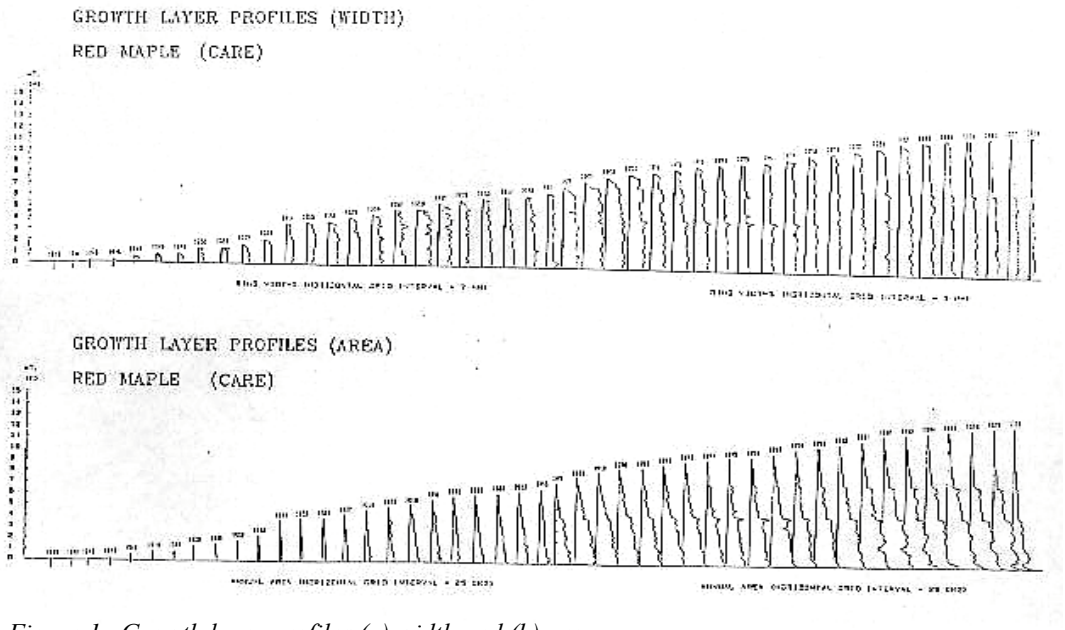

Figure 1. Growth layer profiles (a) width and (b) area.

Figure 1a shows the Growth Layer Profiles (width) for a mature red maple. This tree's age can be traced back to 1943. It shows a slow establishment phase for the first seven years until 1949. After that point, it added incrementally larger ring widths along the length of the tree stem. The tree experienced some excellent growth years in 1956, 1957 and in 1960, but showed net annual decreases in ring width from 1958-59 and 1961-66. The most striking decreases during that period occurred in 1962 and 1966. The tree started to respond and recover from 1967-69 and then less noticeably from 1980-82. The period from 1970-79 and 1983-88 showed overall annual decreases in growth. In 1988, there was hardly any ring width along the stem.

When we examine the GLP (area) (Figure 1b), we can see that the upper portion of the stem is never fully developed. There was more growth in the lower branches than in the upper. The shape of the profile reflects a relatively long crown; the upper crown is severely affected by an impact on the stand, perhaps suggesting that there was reduced space to grow and/or reduced light from stand closure (species-spacing). This type of growth layer profile shows typical growth and development patterns of a tree in an unmanaged forest stand.

Forest Soil Buffering Capacities

Figure 2 illustrates the buffering capacity of forest soils. The buffering capacity is at a 2:1 ratio. For every two-degree change in temperature in the open, there is a one-degree change in the forest. This suggests that our forests can potentially have a profound buffering impact on changes in climate. This buffering capacity protects animals from overly rapid temperature increases and mitigates the effects of climate change on human populations by providing an oasis with a cooler climate.

Snow cover provides additional buffering capacity; it can act as an insulation layer for many species during their life-cycle. The impact of global warming in the lower boundary layers of the atmosphere will directly affect temperatures in open areas and, to a lesser degree, in forest environments. However, as changes in the landscape can lead to increased fragmentation of forest areas, global warming and changes in snow cover

will directly impact the survival and development of native biodiversity. Invasive alien species, which are more readily suited to this new climate, will become increasingly prevalent. A forest climate monitoring programme in highly altered landscapes needs to be co-located in the SI/MAB plots to understand the biometeorological exchanges and processes that affect biodiversity.

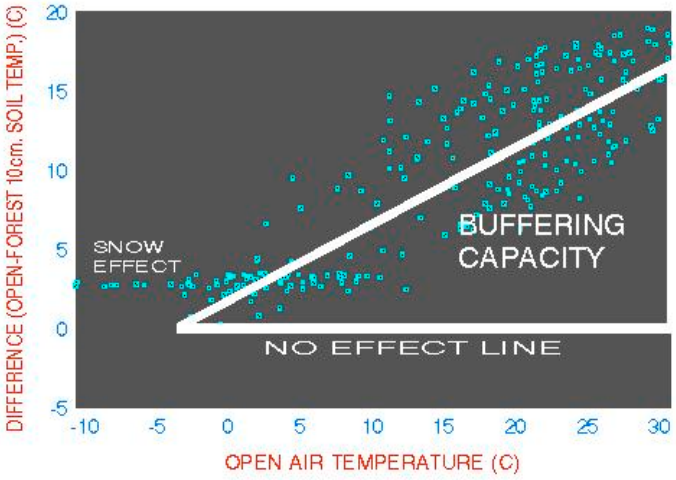

Figure 2. Thermal buffering capacity of forest soils.

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Figure 2. Thermal buffering capacity of forest soils.

Paired Plots

Alice Casselman

Over the past five years, the Association for Canadian Educational Resources (ACER) has developed the capacity to provide complete support for the establishment of new sites along the Niagara Escarpment: From land surveys, such as those done at Brock University and Dufferin County forest sites, to training, community involvement and data collection by community members at Outdoor Education Centres. Each site includes a pair of surveyed plots – one that serves both for demonstration and training, while the other is surveyed, staked and set aside for future research. The research plots, in theory, provide the model and support for the community-based plot.

"Members of the NEBRS project team, which includes authors and teachers, have surveyed a one-hectare parcel of land for study at the outdoor education centre in an effort to observe changes in the trees, birds, plants, climate, and even worms. The plot of land will be made available to community groups, students, teachers and local land owners to use as an environmental training ground." Brian Rodnick, *Orangeville Citizen*, July 23, 1997.

Established in the northern, central and southern areas of the escarpment, the plots provide a natural gradient of biodiversity and climatic conditions for studies of comparative monitoring on a regional scale. These plots are part of an integrated, long-term environmental education and monitoring network and are community-based, serving to link educators, residents and researchers.

"The paired plots have a biological difference, the Mother Nature way and the Human way."
Don MacIver (Wes Keller, *Orangeville Citizen,* Feb 11, 2000).

Mapping along the Niagara Escarpment.

The community-based monitoring programme was built on the premise that laypersons could become accurate data gatherers of forest biodiversity information, provided they were given the right tools and training. It emphasizes the notion that scientists, teachers, students, landowners and the public at large can work together for a common cause – understanding the biodiversity of forest ecosystems through long-term monitoring.

"By setting aside paired one-hectare plots of forested land across the country, one for assessment by the scientific community and one by the general community, ACER and Environment Canada hope to get a snapshot of the health of the forests." John Stewart, *Mississauga News*, Wed. Nov. 1, 2000.

Considerations in the site selection of paired plots are:

1. Vegetation - the site vegetation is typical for the region and similar in both the research and the community plots.
2. Accessibility - the community plot is located very near to the field centre for ease of use in the curriculum.
3. Trails - a trail through the community plot to reduce human impact of students, volunteers and visitors.
4. Staff - experienced outdoor educators who are working in centres with environmental programmes for students and the general public. Note: The pioneer sites were managed by founding members of the Council of Outdoor Educators of Ontario (COEO).
5. Community - individual landowners and volunteers can participate in local community plots long-term data collection and have access to training and scientific expertise.
6. Size - contiguous blocks of forested land, large enough to support resident bird populations.
7. Ownership – land protected for long-term monitoring by ownership e.g., school boards, conservation authorities, agencies and ministries.

Benefits of Involving the Local Community

The community is, in many cases, proactive and ready to participate in important environmental work as was shown in both local telephone surveys and community workshops carried out by Niagara Escarpment Biosphere Reserve System (NEBRS). Because local citizens know the history of the area, they often notice small changes in the landscape more readily than visiting researchers. By their very participation, local volunteers encourage the involvement of other community members to support plot monitoring over the long-term. The greater the number of enthusiastic local volunteers, the greater the chance that the plots will be maintained and monitored over the long-term to provide timely and useful information on changing local biodiversity.

Benefits of Scientists and the Community Working Together

In the paired plot design, scientists can study the effects of human impact on the community plots relative to that in the research or control plots. Scientists from various disciplines can come together to analyse the data collected from the research plots and thereby advance their knowledge of local ecosystem dynamics. Our experience has demonstrated that when scientists use and publish the data collected by local volunteers and students, citizens are motivated to do even more. Meeting the scientists at the site gives the volunteers

Scientists and volunteers at work.

the opportunity to ask technical questions regarding biodiversity, climate change and other ecological issues in a friendly environment.

As part of a Sustainable Communities Initiative (SCI) programme at the Humber Arboretum, the Humber Arboretum and ACER jointly established one set of paired, one-hectare plots. Carol Ray, Special Projects Coordinator of the Arboretum, is very interested in seeing what biodiversity protocols school and community groups implement on their own sites after participating in the monitoring programme at the Arboretum. In the research plot, she is specifically interested in conducting studies on the correlation between the biodiversity of forests and 1) air quality, 2) water quality and 3) wildlife habitat. Since interior forest birds are affected by habitat size, one question she would like answered is "How does human impact in the Humber Arboretum area affect song bird habitat?" Carol Ray thinks that standardized monitoring in these biodiversity plots will encourage better stewardship.

Examples of How Scientists / Researchers are using the Paired Plots

Caroline Mach, Dufferin County Forest Manager, used ACER's technical knowledge to survey and establish two biodiversity research plots. One is the research plot, paired with the Mono Cliffs Outdoor Education Centre community plot, while the other is a research plot to study maple-beech forest natural regeneration. John Middleton of Brock University also used ACER's survey team to establish two plots, one on Brock University campus for student course work, the other in Short Hills Provincial Park.

Other potential research plots have been staked and surveyed in and around the Niagara Escarpment area (in association with community-based plots at Education Centres) in the hope that independent researchers will choose to use these surveyed sites.

By pairing research and community-base plots, comparable and compatible data collected from these plots will be generated and both scientists and community volunteers may begin to learn how human impact affects local biodiversity.

SI/MAB in the Yukon or, How to Measure Lots of Little Spruce Trees on Hills

Joan Eamer

Background

Two SI/MAB plots were established (starting in 1997) in the Wolf Creek Research Basin, in the Boreal Cordillera ecozone, near Whitehorse, Yukon. These plots form part of a developing forest biodiversity monitoring programme for the Research Basin. Objectives are to:

1) track changes in the Boreal Cordillera forest ecosystem;
2) develop an inventory of species and habitats;
3) establish a framework for integrated research; and,
4) contribute to community education on ecosystem and biodiversity issues.

Environment Canada designs and manages the SI/MAB programme, but credit for most of the hard work goes to youth crews, especially through the Yukon Youth Conservation Corps (Y2C2).

Notes on SI/MAB Methods

Applying a methodology designed for tropical rain forests to northern coniferous forests poses some interesting challenges. In other words, it isn't quite how it looks in the book. Forests around Whitehorse are patchy, dense and slow-growing. Listed below are the accommodations that we made to adapt the SI/MAB methodology to these conditions.

Patchiness (variability in forest communities related to elevation, aspect, soil types)

A vegetation classification was developed for the Wolf Creek Watershed, based on aerial photographs, a digital elevation model and limited ground truthing. One plot was established in each of two of the five forest vegetation classes. We first attempted to randomly select points within these classes and use these as corners of plots, but this did not work (they were either too difficult to get to or were less than a hectare in size). We eventually identified on the map all areas with relatively large blocks of each forest type that had reasonable access and that were fairly close to the climate station. We then walked through each of these blocks and paced and flagged possible one-hectare plots that were not along gradients or broken by stands of another forest type. The final selection was based on ease of access and homogeneity. It would not be possible to establish multiple contiguous plots in this type of terrain.

Verifying quadrat map, Wolf Creek.

Dense Growth (2600-3700 tree stems per hectare)

Surveying the Plots: With the volunteer help of professional surveyors, we first established the perimeter of each plot. To ensure a quality survey, we had to have a clear line of sight along each of the four border lines. This required cutting down some trees. We then worked our way inwards from each of the border lines by a combination of line-of-sight surveying and chaining across quadrats where vision was limited. No vegetation was cut inside the plots.

Mapping the Trees: High tree density also made mapping tree positions difficult, as it was often impossible to see two corners of a quadrat and trees were often only centimetres apart. To provide a frame for each quadrat, we established clearly-visible perimeter lines for the quadrats using string and flagging tape, with one colour for north-south lines and another for east-west lines. The most efficient mapping method was to first map most of the trees by triangulation with range finders and occasionally tape measures, enter the data and print a map, then return to the quadrat with three people – two to read the tree labels and measure distances from the perimeter line, and one to correct positions on the map. This process had to be repeated at least one more time before a reasonably accurate quadrat map was produced.

Slow Growth

Although the SI/MAB standard for including a tree in a plot is 10 cm diameter at breast height (dbh), many plots in Canada include trees down to 4 cm dbh. We decided to reduce this further to a minimum size of 2.5 cm, as a tree of that size may be 10 to 20 years old. This is consistent with the minimum dbh used for forest inventory plots in this region.

Other important discoveries made by our crews

1) Mosquito repellant dissolves the plastic coating of range finders.
2) Make sure at least half the crew is awake when the leader explains which scale to read on a clinometer.
3) Allow for a 10% loss of crew members through being driven mad by range finders that work only intermittently (possible relationship with point 1).
4) You always run out of tree-marking paint and radio-phone batteries simultaneously .
5) Squirrels and ravens love shiny aluminum tree tags.
6) If a moose walks through your plot, you will need to erect most of the 1.2 km of string along the quadrat perimeters all over again.
7) If you wear a bug hat your vision is impaired and you tend to fall over things and land in rose bushes.
8) If you go to the trouble of numbering, measuring, tagging and mapping a small, dead, half-rotten spruce – don't then lean against it.

And finally, if anyone ever finds the live standing *Picea glauca* number 76 in Quadrat 11 of Plot 1, please let us know.

Bioregional Mapping On Toronto Island's Biodiversity Plot

Marianne Karsh

As part of Arborvitae's Cosmic Camp For Kids and Youth Training Programme 2000, the youth team completed a Bioregional Map of the Toronto Island SI/MAB Biodiversity Plot (Figure 1).

Bioregion means "life place" and the term bioregionalism is a call for us to become knowledgeable guardians of the places where we live; encompassing not only the local land, but our local water, weather, sky, plants, animals, neighbours and communities. Although we are seldom aware of it, we live in naturally unique physical, ecological, historical and cultural areas whose boundaries are more often ridgetops than county lines and state borders.

The concept of Bioregionalism, or 'living a life dedicated towards the reintegration of human and non human relationships in place', includes four main components.

1. *Knowing the Land* - gaining familiarity with the landscape by creating a wildlife species list, a record of rainfall, waterflows, monthly climate conditions, historical events, native settlements, potentials for using clean energy, etc.

2. *Learning the Lore* - gaining an understanding about the history of one's life-place from libraries, city archives, museums and area residents.

3. *Developing the Potential* - discovering how well resources are used in the bioregion with the understanding that "A bioregion used to its potential will encourage and demand full development from its human and non-human inhabitants," (Sale, 1985).

4. *Liberating the Self* - seeking opportunities in the bioregion to live closer to the land and becoming less dependent on market forces, global economic/political forces. Feeling connected to the land provides a sense of 'rootedness' and a new meaning of life and place. "It is not difficult to imagine the alternative

to the peril the industrio-scientific paradigm has placed in us. It is simply to become 'dwellers of the land'," (Sale, *1985*).

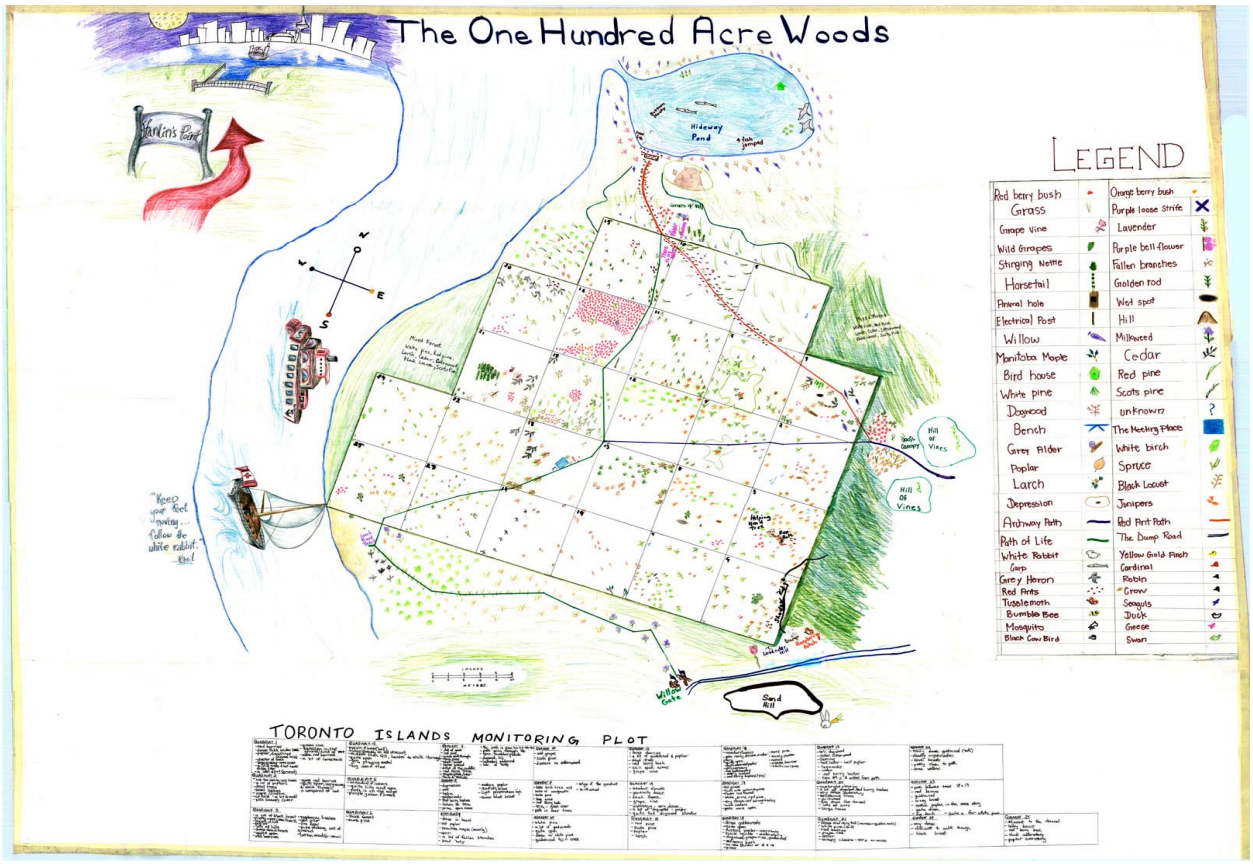

Figure 1. Bioregional map of Toronto Island SI/MAB plot.

Community-based bioregional mapping, a technique at the cutting-edge of contemporary western planning thought, is compatible with indigenous land stewardship regimes.

Bioregional maps communicate a story both in images and in words; spatial information such as the location of special things or events are labelled on the land while information about events is written in a story format. Whenever people look at maps they are reminded of stories about certain places. For example, people might have stories about a particular stand of trees and what it means to the community, which they would record on the map. The map could show natural features such as soils, landscapes, vegetation and wildlife, as well as ways that people in the community use the land.

Once a bioregional map is complete it becomes the foundation of knowledge from which planning scenarios can be prepared. The community learns about itself in the process of making decisions about its future.

By the community

Bioregional maps provide communities with a medium through which they can describe themselves and provide their own unique perspective. Bioregional mapping is done by ordinary citizens who rediscover local places through their map-making explorations, often requiring the application of appropriate scientific disciplines like geology, geography, hydrology, biology, forestry and anthropology.

Why do it?

Water and soil dynamics are key parameters in determining use of the land. Without this knowledge how can we even begin to comprehend how to use the land wisely?

One of the most fascinating things about discovering one's bioregion is that the acquaintance process never ceases – there is always more to discover. The process of learning about and appreciating our natural community effortlessly leads to a desire to protect and care for it. Building our awareness of an ecosystem's intricacies without changing or altering it leads to an understanding of how it operates and how we can better relate to it. The more you know the ecosystem the more you care about your impact on it (Bioregional Club in the U.S.)

"I'm learning something general enough to be able to apply these values to any other place my life takes me," Dan Spurgeon says. "Having respect for an ecosystem makes me feel like a part of me will never leave."

“Our goal in Bioregional Mapping was to develop the deep sense of respect and appreciation, which is really at the core of our being. It is where our spirit is. Only out of that appreciation will we learn to really care for the universe. We might do it out of a sense of responsibility but sometimes we resent responsibility. If we do it out of love and deep appreciation we'll learn to really care about it,” Janet Fraser, Cosmic Camp for Kids.

"I went into the woods because I wished to live deliberately, to front only the essential fact of life, and see if I could learn what it had to teach, and not, when I come to die, discover that I had not lived," Henry David Thoreau.

As part of the Bioregional Mapping project on Toronto Island, the Arborvitae youth team designed a questionnaire and interviewed Toronto Island residents. The questionnaire and interviews were a highlight of the exercise because the community became more deeply involved.

Combining the Bioregional Mapping with a SI/MAB Biodiversity Plot was an excellent way to facilitate the experience because the land and trees were already mapped and surveyed. The one-hectare plot size provided an increase in the number of opportunities for the youth to deepen their knowledge of the site by recording the plants, animals, water health, human impact, favourite places and stories of this bioregion. In addition, the Arborvitae youth team received training from EMAN staff and partners, and in return collected additional tree measurements, tested new protocols and produced a unique Bioregional Map for the site.

References

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Sale, K. 1985. Dwellers in the Land: The Bioregional Vision. Philadelphia, PA. and Gabriola Island, BC., New Society Publishers.

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Figure 1. Bioregional map of Toronto Island SI/MAB plot.

ANALYSING AND APPLYING COLLECTED DATA

The following three documents provide analysis and application of the forest biodiversity monitoring system. Don MacIver relates monitoring to the idea of biodiversity while Marianne Karsh gives an example of how the SIMAB plot data can be used for comparison and discussion on the state of Canadian forests.

The Biodiversity Issue

Don MacIver

Introduction

At the United Nations Conference on Environment and Development (UNCED) in 1992, more than 156 countries and the European Union signed the Convention on Biological Diversity. The Framework Convention on Climate Change and the Statement of Forest Principles were also part of the Rio Declaration, Agenda 21.

Canada, in the same year, ratified its commitment to the Convention on Biological Diversity through the production of two key documents: The Canadian Biodiversity Strategy and The Science Assessment on Biodiversity.

The current decline of global biodiversity is a strong cross-cutting issue that is intended to integrate decision-making and mobilize individuals and agencies. Canada, like many countries, recognized the significance of this global biodiversity challenge, including the difficult task of integrating many diverse science and policy issues. To some, this was seen as an exercise to build cooperative policy structures and management agreements but to others, it was a singular opportunity to integrate and share biodiversity observations and knowledge in the field, the laboratory and the classroom.

The Canadian Biodiversity Strategy

Canada, by ratifying the Biodiversity Convention, committed itself to the development of a national strategy. Beginning with numerous intergovernmental and scientific focus groups, the Canadian Biodiversity Strategy emerged as an implementation guide with the following vision (BCO, 1995):

> ***A society that lives and develops as a part of nature, values the diversity of life, takes no more than can be replenished and leaves to future generations a nurturing and dynamic world, rich in its biodiversity.***

The Strategy's five goals are:

- conserve biodiversity and use biological resources in a sustainable manner,
- improve our understanding of ecosystems and increase our resource management capability,
- promote an understanding of the need to conserve biodiversity and use biological resources in a sustainable manner,
- maintain or develop incentives and legislation that support the conservation of biodiversity and the sustainable use of biological resources and
- work with other countries to conserve biodiversity, use biological resources in a sustainable manner and share equitably the benefits that arise from the utilization of genetic resources.

Each of these five goals were then identified under the broad titles of conservation and sustainable use, ecological management, education and awareness, incentives and legislation, and international cooperation. Each contains a series of sub-headings, such as protected areas, atmosphere, traditional knowledge and implementation, ending with a national strategy containing more than 100 recommendations.

Under the direction of the Canadian Biodiversity Office, the federal, provincial and territorial governments have now signed the 1995 Canadian Biodiversity Strategy. As an over-arching document, it serves an important role in identifying international and national contexts for biodiversity, defining the vision and outlining many directions for biodiversity conservation.

Two strategic directions were identified in Canada. The first, the sector approach, promotes the integration of biodiversity conservation into management agencies such as agriculture, forestry, aquatic and so on. The second, the ecoregion approach, using the ecological framework, functionally integrates science, issues, agencies and people within and across ecological boundaries.

Science Assessment on Biodiversity

During the same period, a science team composed of government, university and private sector scientists was commissioned by Environment Canada to undertake a science assessment. Quite different from the strategy document, the science assessment reviewed our current scientific understanding and offered recommendations that were specifically targeted at relevant science and policy initiatives (BSAT, 1994).

The 215 page assessment, with an accompanying 15 page executive summary, included a conceptual overview followed by specific chapters that focused on the compatibility of major land uses with the protection of biodiversity and environmental stressors, such as genetically modified organisms, environmental pollutants and atmospheric change. The science team met frequently to consolidate, review and improve their common understanding and assessment of the science of biodiversity in Canada.

The science assessment chapters were submitted for peer review, followed by a policy workshop. The final assessment contained both science and policy recommendations and, more importantly, the science-based rationale for the proposed actions. The science assessment has been well received nationally and internationally.

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Biodiversity Convention Office (BCO). 1995. Canadian Biodiversity Strategy. Biodiversity Convention Office, Environment Canada, Ottawa, Ontario.

Biodiversity Science Assessment Team (BSAT). 1994. Biodiversity in Canada: A Science Assessment for Environment Canada. Environment Canada, Ottawa, Ontario.

Biodiversity Framework

Don MacIver

The Canadian Biodiversity SI/MAB network continues to expand at an unprecedented rate. Numerous agencies, using the SI/MAB protocols, have established the one hectare plots in forest environments or smaller biodiversity plots in grassland and tundra locations. The goals and objectives of each group are different, hence making it difficult to communicate respective methodologies and results in a common room in spite of the common topic – biodiversity.

For this reason, a framework was established to emphasis the diversity of goals and objectives faced by different groups using the same biodiversity plot. This framework is illustrated in Figure 1 (MacIver, 1998).

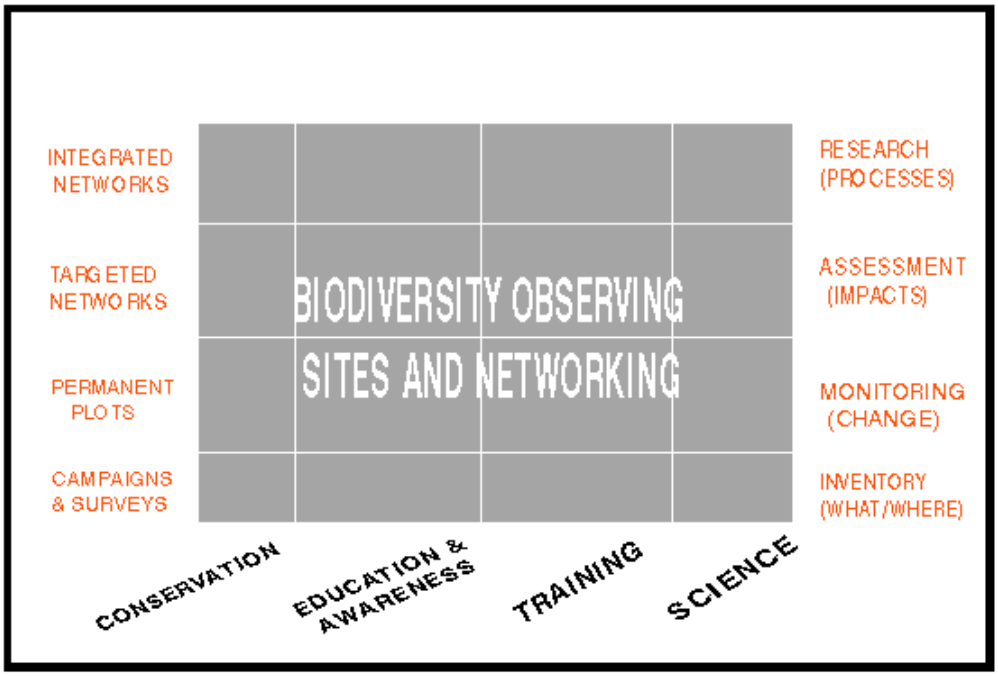

Figure 1. Biodiversity framework grid.

Conservation is, the idea of using the International SI/MAB plots to contribute to the continued protection of biologically diverse areas or to set aside land for long-term monitoring (i.e. as part of a land trust holding).

The education and awareness category is by far the most aggressive with SI/MAB plots established by outdoor education centres, urban and rural schools and universities.

The training courses are increasing in demand and frequency. Quality control standards are important for the subsequent electronic sharing of the biodiversity observations and scientific data bases. This component provides a unique opportunity to "train the trainers" using science-based protocols. In other words, these sessions are an important bridge between the science and educational categories.

The Science category is the most limited in terms of the number of sites, but highly integrated scientifically. Locations, such as Kejimkujik National Park in Nova Scotia or the Centre for Atmospheric Research Experiments (CARE) in Ontario are excellent examples of collaborative biodiversity research, using paired plots to evaluate the unmanaged versus managed forest biodiversity.

The other axis in Figure 1 serves to highlight the many goals and objectives with the bottom two levels focusing on structure and the upper two levels focusing on process. This matrix approach has proved effective to help people rationalize their goals, objectives and monitoring deliverables. Understandably, as the direction increases from left to right or bottom to top, an increasing level of expertise and resources is required, now or in the future.

Many agencies commonly establish at least two SI/MAB plots, one for education or eco-tourism and the other co-located as a research benchmark. This is design has worked well, especially throughout the length of the Niagara Escarpment centred around outdoor education centres (i.e. ACER). Data collected by scientists or trained volunteers is first audited and accredited before being exchanged on the Internet, locally, regionally, nationally and globally via EMAN.

References

MacIver, D. 1998. Atmospheric Change and Biodiversity. Environmental Monitoring and Assessment, 49:177-189.

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Figure 1. Biodiversity Framework grid.

National Comparisons

Marianne Karsh

Canadian SI/MAB Baseline

The Canadian SI/MAB baseline operates within the context of a global biodiversity programme to better understand the state of biodiversity using the same standardized monitoring protocols. Also unique to this programme is the recognition and usability of information collected throughout Canada from numerous participants with various levels of scientific knowledge and experience. This means that quality assurance, redundancy, auditing and certification has been incorporated into the programme to support this evolving Canadian baseline.

The Canadian SI/MAB baseline is represented by observation sites from coast to coast with the predominance of sites in Ontario and Québec. Appendix B provides a complete list of evolving and known SI/MAB sites across Canada. It lists a total of 88 sites in the Canadian SI/MAB baseline with Ontario and Quebec representing 60% of them, the Maritime Provinces representing 16% and Western Canada, the Prairies and the North representing 24%. The Analysis Section, reports on 37 SI/MAB sites where data is available for analysis (all sites in Table 2) which includes 20 sites in Ontario (two set of measurements for Backus Woods), nine in Quebec, four in British Columbia, two in New Brunswick and one each in the North West Territories and the Yukon.

This has been a very successful programme with sites being established at an incremental rate from 1994 to 2001 (see Table 1).

Year	# of Plots	Location(s)
1994	2	Kejimkujik National Park, NB
1995	6	Long Point ON , Rockey Point BC
1996	13	Mingan QB, Grosse Ile QB, Lauentides QB, La Mauricie QB, Forillon QB, Boyne ON, Wiarton ON, Mono Cliffs ON, Ganonque ON, CARE ON, Bruce Peninsula ON.
1997	10	Botany Bay QB, Lake Hill QB, Wolf Creek YK, Royal Botanical Gardens ON, Tiffin ON, Toronto zoo ON, Cabot Head ON, Hitlon Falls ON, Hockley Valley ON, Skinners Bluff ON.
1998	0	
1999	6	Chalevoix QB, Galiano BC, Brock ON, Gwich'in NWT

Table 1. Chronological list of the 37 sites used for data on national comparisons

The SI/MAB sites have been established for a variety of reasons including research, education, training, protocol development, emerging issues and adaptive management. Since biodiversity is a relatively new emphasis in science, it follows that the bulk of the comparison sites were put in to answer research questions. For example, 24 SI/MAB sites listed research as the primary reason for plot establishment. The majority of the research questions centred around ecosystem processes such as:

- What is the structure and function of a natural aspen forest ecosystem?
- What is its prognosis with climate change?

- What will be the rate and nature of species change over time?
- What are the indicators to climate change?
- How will community dynamics be affected by climate change?
- What are the long-term changes in forest population dynamics?
- What are the changes and successional patterns of an undisturbed alluvial West Coast Temperate Rainforest?
- How will the Boreal Cordillera Forest Ecosystem change over time?
- What is the long-term successional trend in the black-spruce forest cover type?
- What is the structure and function of a natural mixed conifer forest ecosystem?

Other research questions focused on impacts such as:

- What are the long-term cumulative environmental effects of land use change and development on biodiversity?
- What are the effects of environmental changes on ecological communities that may result from such pressures as population growth or global warming?
- What is the impact of the Dutch Elm disease on diversity?
- What is the baseline for biodiversity of species/habitats?
- Will prescribed fire restore the diversity of grassland communities?

Fourteen sites were established with education and awareness as the primary purpose in mind. Impact assessment came next with five sites and conservation with three, training, adaptive management and emerging issues were each listed as the primary reason in at least one site.

Sixteen of the sites listed training as their secondary purpose and the SI/MAB sites were noted for serving this purpose particularly well. The remaining categories of secondary purposes were research (12 sites), conservation (8 sites), education/awareness (6 sites), impact assessment (5 sites) and emerging issues (2 sites). There are approximately 12 locations with climate stations. These are located in Fundy National Park, Wolf Creek, Terra Nova National Park, La Mauricie, Laurentides, Wilson Tract, Oxbow Woods, Mixed Conifer Site at Yoho, Tiffin, CARE, Kejimkujik, and Clayoquot. Half of Canada is forested and yet few long-term and paired bioclimate stations operate within the forest structure to understand its buffering capacity resilience to atmospheric change (MacIver et. al. 1994). This monitoring programme is very unique with climate towers co-located inside of the forest biodiversity plots and is a major step forward.

The SI/MAB Baseline shows a high predominance of sites with sugar maple (*Acer saccharum*). Seventy-six percent or 28 out of the 37 sites have trees in the Acer species group (Table 2). The majority of these stands are composed of 70 - 92% sugar maple with 24 of the sites having > 100 maple trees/ha. This is significant since the rest of the database has an average of three sites with > 100 trees/ha composed of non-maple species. Other species groups that show a moderately wide distribution through the database are Betula, Fraxinus, Fagus, Abies and Quercus.

Of the 42 sites shown in Table 3, 14 of these have >1000 stems/ha. This ranges from 339 stems/ha in the prescribed burn plot at Turkey Point to 2521 stems/ha in Charlevoix. As a comparison, the sites in Limbe, Africa and Dinghusham, Asia have an average of 1223 and 3960 stems/ha respectively. The average diameter/stem ranges from 11.1 cm/stem in Charlevoix to 52.3 cm/stem in CARE (Plot 1). The greatest basal areas were found at the two CARE plots, approx. 300 - 400 m^2/ha. Most of the sites has between 23 - 86 m^2/ha.

Comparisons of Diversity in Canadian SI/MAB Sites

Carolinian Forests

There was a striking difference between the diversity of oak and maple stands at Long Point, Ontario especially between managed (prescribed-burn) and unmanaged sites (Figure 1). There were five versus 12 families (oak dominant versus maple dominant stands) and three families compared to five (Turkey Point

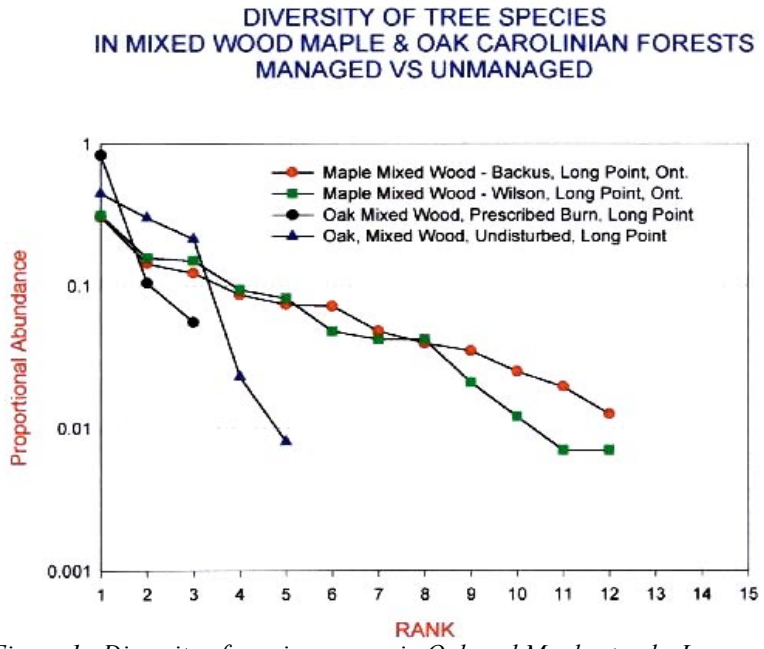

Figure 1. Diversity of species groups in Oak and Maple stands, Long Point.

plots managed and unmanaged). Today Carolinian forests survive only in scattered woodlands in southern Ontario. The Carolinian, hickory - sugar maple and basswood - sugar maple forest ecosystems are rapidly disappearing in Canada. Land conversion to urban and agricultural uses has severely fragmented the remaining forests. Backus and Wilson sites at Long Point, an important Biosphere Reserve, show a typical mixedwood diversity for this region with approximately 12 families (i.e. 12 groups of completely different species groups such as Oak sp., Pine sp., and Cherry sp).

Niagara Escarpment - Sugar Maple

The Niagara Escarpment, extending from the Niagara River to the tip of the Bruce Peninsula, is in a region of high risk to the loss of biodiversity. The curves for Escarpment forests are very similar and represent five sites on a North/South transect along the Escarpment (Figure 2). These are all representative of sugar maple stands with nine families in Hilton Falls and seven at the Royal Botanical Gardens. Most of these sites, including Skinners Bluff, Cabot Head and Hockley Valley have five families and a relatively high proportion of native biodiversity.

Over 31% of the plots in the total database are sugar maple (*Acer saccharum*) forests. Sugar maple is typically associated with the latter stages of succession and is one of the most important hardwood species in Eastern Canada, valued for its wood and syrup. Canada produces between 80 and 85% of the world's maple syrup (CFS, 1999). The North American Maple Project also monitors change in these stands. Because of the high proportion of existing SI/MAB plots in sugar maple stands, priority should be given to other forest types and the establishment of

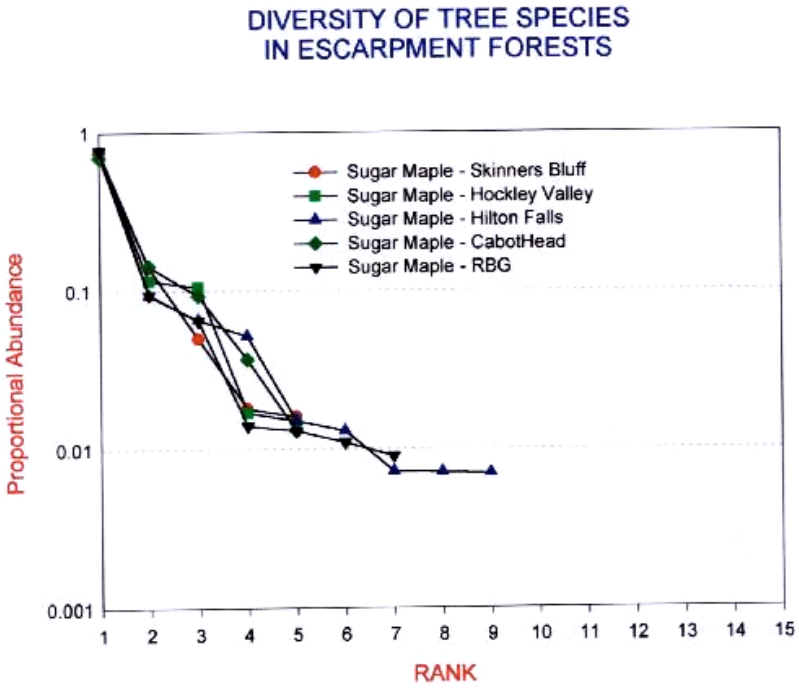

Figure 2. Diversity of species groups in Sugar Maple forests along Niagara Escarpment.

additional biodiversity plots in stands with greater than 60% sugar maple should be low priority. Other sugar maple sites in this region (Figure 3) are Wiarton, Bruce National Park, Cabot Head, Toronto Zoo and Mono Cliffs (which is represented as a single point as the site has not started to diversify). All diversity curves were similar with the most different being associated with the site that had the greatest human impact, the Toronto Zoo site. If there are no invasive species occupying the site due to impact, diversity appears to decrease with increasing human impact or pressure on the site.

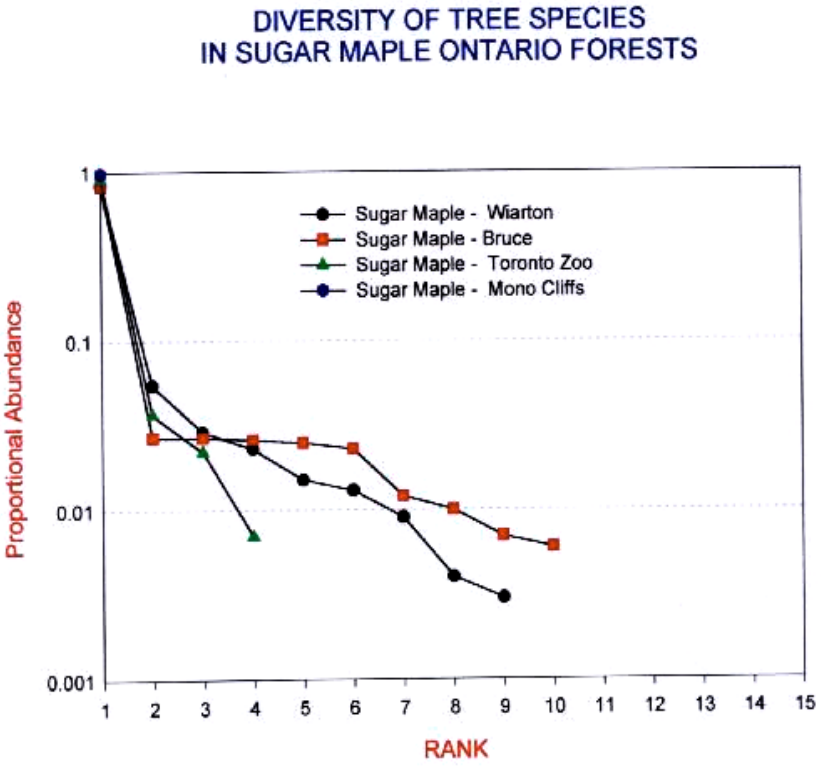

Figure 3. Diversity of species groups in Sugar Maple forests in southern Ontario.

There is a need to measure and record the level of human impact on these biodiversity plots. There should be a record form for each site to identify the levels of traffic and human impact. Human impact causes irreversible losses of biological diversity; this means extinction of species and populations and loss of ecosystems (e.g. Carolinian). Fragmentation of natural landscapes is considered one of the most important factors contributing to the loss of biological diversity. Human impact accounts for losses between 1/2 to 1/3 of the land surface. Some of mixedwood sites, particularly in the south, have some of the highest diversities of breeding birds. The habitats of many of these bird species are being placed under increasing levels of stress as a result of agricultural and industrial development. Introduced species of vascular plants invading some pristine forests are a threat to stand biodiversity (Middleton and McLaughlin, 1994).

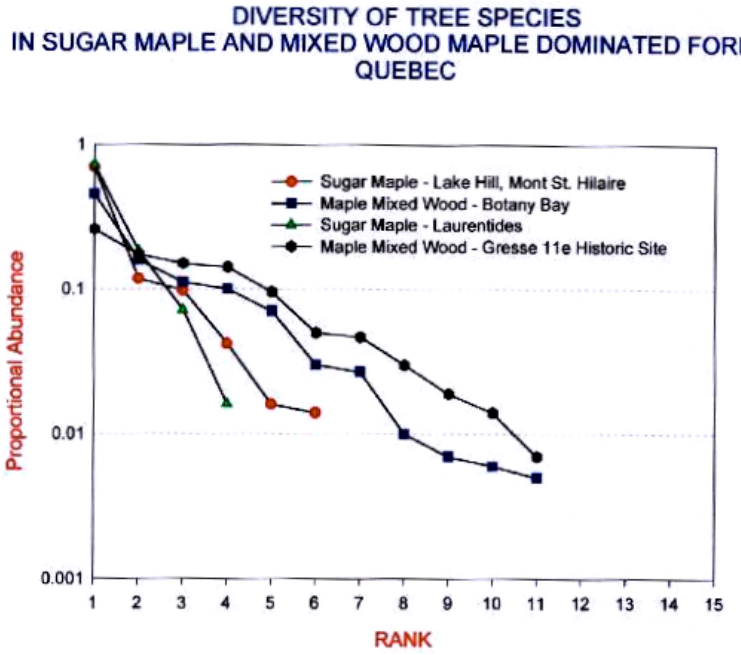

Figure 4. Diversity of species groups in Maple sites in Québec.

There is a striking comparison between the sugar maple sites in Québec (Lake Hill, Laurentides) and the maple mixedwood at Botany Bay and Grosse Ile (Figure 4). The sugar maple sites have four to six families compared to 11 families in the maple mixedwood stand.

In addition, the maple mixedwood sites are located at Ganonoque, Tiffin, Backus and Wilson. They have very similar patterns of proportional abundance (Figure 5). All have about eight to 12 families, with the greatest number of families in the Carolinian forest. These maple mixedwood sites show the greatest diversity in terms of families. At least four families tend to be high in proportional abundance (between 0.1 and 1) with approximately nine that are lower in abundance (between 0.01 - 0.1).

Northern Forests

There are two plots in predominantly white spruce (*Picea glauca*) stands (89 - 99%) at Gwich'in , NWT and Wolf Creek in the Yukon. Both stands have a small component of willow (*Salix sp*.). Poplar (*Populus sp*.) is only present at Wolf Creek. These forests are typical to the region where there is a predominance of natural single species forests that have adapted to the ecology of the region. There are one to three tree families in these sites. The number of species decreases as you go further north in the Boreal Cordillera Ecozone. There is a high predominance of forests populated by a single tree species (i.e. monocultures) in the North Boreal/Barren areas.

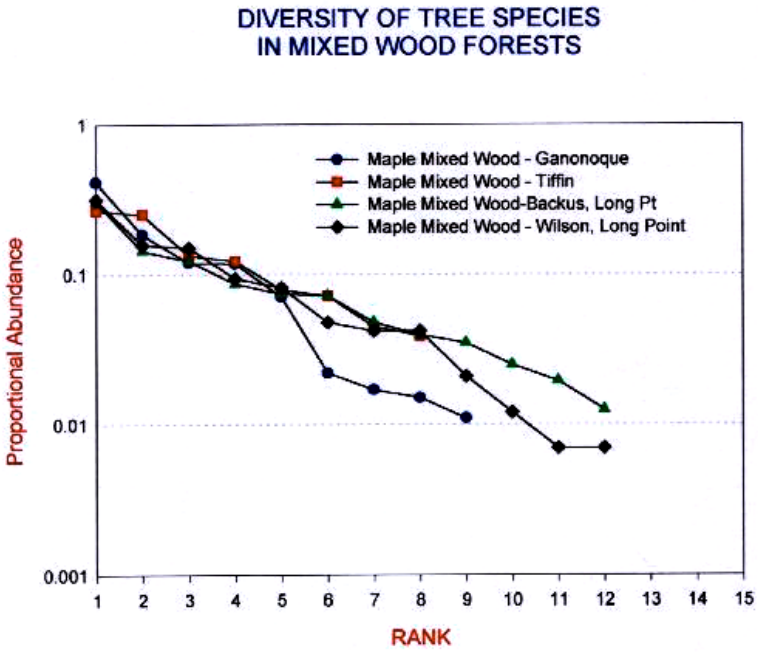

Figure 5. Diversity of species groups in Maple Mixedwood forests.

Permanent shifts from softwood to hardwood cover is occurring in areas where harvesting has replaced fire as the dominant disturbance. Clear cutting, because it does not mimic the ecological effects of fire, sometimes results in a fundamental ecological shift in fire-dominated ecosystems. The combination of clear cutting and fire suppression favours establishment of trembling aspen and white birch to the detriment of conifer species such as black and white spruce and jack pine (CFS, 1999).

There are three plots in black spruce (*Picea mariana*) forests: two at Charlevoix and one at La Mauricie. These stands have between one to four families with an extremely high composition of spruce (>95%). Balsam fir also occur at the two sites (<1%). La Mauricie has two additional families, white pine (< 1%) and poplar (<1%). These sites have an average of 2200 stems/ha. Since this is such an extensive and important ecosystem and there is only one species on the site, black spruce represents the benchmark species for forest diversity curves in Canada.

Old Growth, Rare, Endangered or Endemic Populations

Old stands are not necessarily particularly rich in species, but some species are clearly dependent on them. (Middleton & McLaughlin, 1994). The old growth Douglas fir site in British Columbia had four families, the new Douglas fir regeneration site had five families (Figure 6). Old growth forests survive only in patches in the three Maritime provinces and small stands of old red and white pines in central Canada. The number of pristine temperate west coast rain forests keeps shrinking. In the coastal temperate rain forest of British Columbia previously unknown invertebrate species, unique to the canopies of coastal old-growth forests, have recently been identified (CFS, 1999).

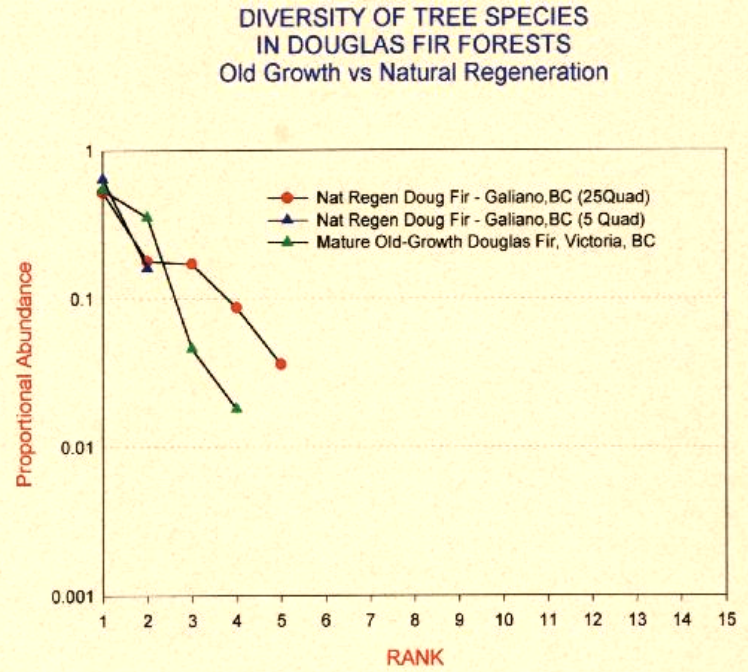

Figure 6. Diversity of species groups in Douglas Fir forests

For example, the Garry oak - arbutus ecosystem in the Pacific Maritime Ecozone, specifically on southern Vancouver Island and the Gulf Islands, is one of the rarest ecosystems in British Columbia and does not occur anywhere else in Canada. That existence of endemic species (ones found only in a particular habitat) may be a signal that an unusual habitat has developed. Urbanization, invasion by exotics and agricultural activities are all contributing to its degradation (CFS, 1999). Fire suppression has allowed invasion by Douglas-fir. Overgrazing by livestock and the eastern cottontail rabbit, an introduced species, have created conditions for the establishment of many non-native plant species. European gypsy moth and Scotch broom, both non-native species introduced through human activity, are also continuing threats to native species (CFS, 1999).

With the Garry oak and Douglas-fir sites on the West Coast, the curves in Figure 6 are typical for a single species. There is a high proportion of one or two families and then the curve drops rapidly. The other two to three families are in relatively low proportions in the understory. There are two plots at Royal Roads. The three predominant families in both plots are western red cedar, grand fir and coastal Douglas-fir. In Plot 2 there is almost twice the number of coastal Douglas-fir. Plot 1 has two other families, red alder and western hemlock. Plot 2 has six more families: cherry, western yew, red alder, arbutus, bigleaf maple and apple species.

Centre for Atmospheric Research Experiments (CARE)

This managed red pine plantation forest was established in 1937 and began with red pine making up 100% of the species in the site. At the CARE site there are currently eight families (Figure 7). There was an addition of seven more families in this stand between the time it was planted and 1988. Thus, we can ascertain that a managed plantation, if left unmanaged (i.e. no thinning or pruning later on in the stands history and no removal of dead or dying trees) will tend toward increasing biodiversity. It took about 60 years for the natural re-introduction of seven new species into this stand. This natural rate of biodiversification is too long compared to the impacts and stresses occurring with the anticipated rate of climate change. The rate that it takes forests to diversify is hundreds of years. This highlights a potential maladaptation

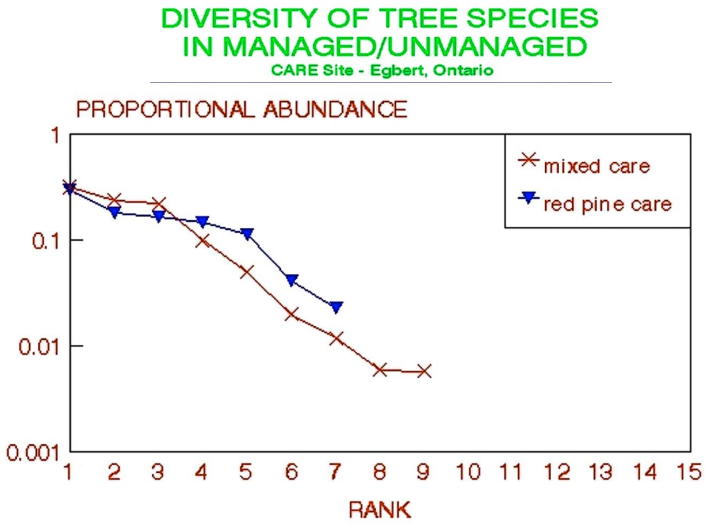

Figure 7. Diversity of tree species in managed/unmanaged CARE plots.

process in forests stands and suggests a very strong need for human intervention (i.e. taking steps to increase forest adaptivity by planting for diversity). Three families show a high proportional abundance and the rest show relatively low abundance. For CARE it took 60 years for seven more families to occupy the stand. It will take at least another 100 years for trees in the understory to mature so that the canopy will become a true mixedwood canopy.

Canadian Benchmark and Comparison to International Sites

The conservation of a single species in a northern ecosystem may be more critical to the way that ecosystems function than a single species in a highly diverse tropical ecosystem, with its abundance of species and genetic variations. Canada can ill-afford to lose one species in a climate where species are adapted to harsher conditions. It also contains free-ranging populations of large mammals, such as polar bears, grizzlies, caribou and wolves. Latitudinal gradients of diversity have been shown from high in the tropics to low in the Arctic. In Peru there was an average of 152 different plant species per hectare with a diameter of 10 centimetres or more. An average of 18 species per hectare are found in northern Europe and 29 in the eastern United States. The average number of tree species found in Canadian plots is 11, with a range of 2 to 22.

Black spruce at Charlevoix is an important Canadian Benchmark: however, this is only one tree family compared to more than 50 in the Dinghusham area in Asia (Figure 8). (Note - Limbe, Africa includes trees smaller in size than 10 cm dbh while all the other curves on this graph (including the Canadian sites) are calculated for trees 10 cm dbh and higher).

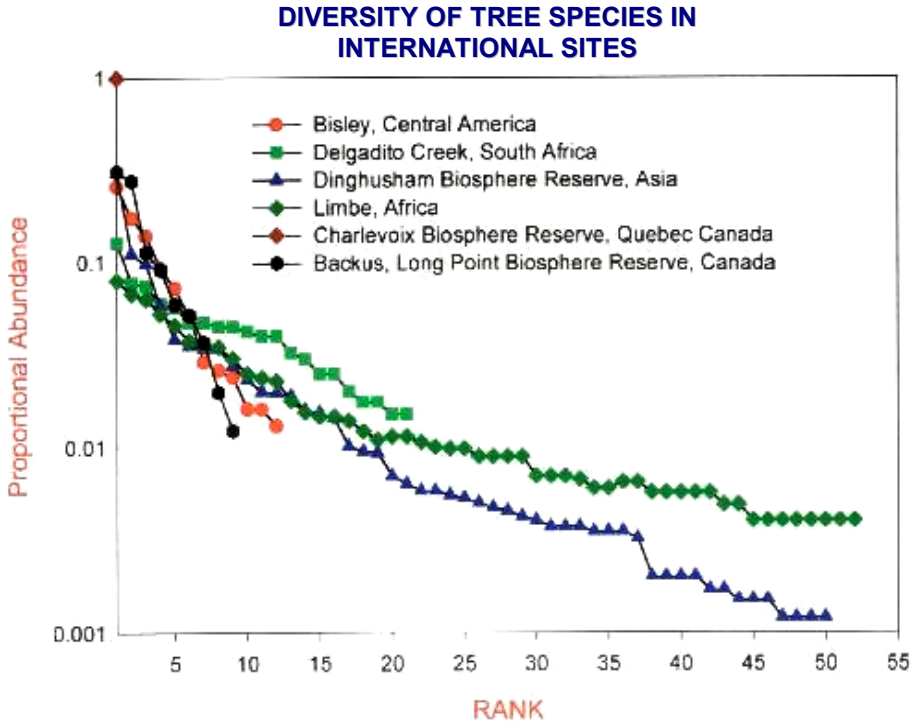

Figure 8. Diversity of tree genus groups at six international sites. Most abundant species is given a rank of 1; minimum threshold of 5 trees per species group.

This value of 10 cm dbh was used as the cut-off value since it is the adopted measurement standard developed for international comparisons and especially for use in the tropics. According to Roberts-Pichette and Gillespie (1999), Canada has adopted two levels; the first being 10 cm dbh and 4 cm dbh for dwarf forests (exceptions being the Far North or stand densities in excess of 3000 stems/ha). If we were to exclude all trees below 10 cm dbh in Canada, in stands with a total density of less than 1000 stems/ha, we lose from 15-60% of the record of biodiversity in the stand (based on SI/MAB data from Backus Woods, Botany Bay, Cabot Head, Wolf Creek, Wilson, Toronto Island, Skinners Bluff and Rocky Point). Backus Woods in the Carolinian region and Bisley in Central America have similar numbers of species (<15) and Delagadido Creek has around 20 families (see Figure 8).

Bio-Climate Comparisons and Adaptivity

Many of the SI/MAB partners were concerned about the adaptivity of our forests. Many scientists are now saying that the evidence is no longer ambiguous: Atmospheric change is a reality and it directly affects the

biosphere and biodiversity. Most key habitats and many species may be subject to some change, coastal areas more than others. Not all species and habitats will be able to adapt to the rate of climate change. Insects and fungi are capable of adapting quickly to a changing environment because of their genetic makeup and short generation times, but trees are much slower to adapt. This difference in adaptive abilities would lead to an increased risk of insect and fungi infestation with a changing climate (CFS, 1999).

Deteriorating atmospheric quality, evidenced by increased air pollution, acid rain and ultra-violet radiation, is having a negative impact on many species. The consequences of air pollution may be even more severe for longer-lived species such as trees, which have longer exposure to atmospheric pollutants. In the absence of increased disturbance, lag effects of the vegetation and, perhaps animals, will decrease the speed of response and increase the persistence of flora and fauna to be out of equilibrium with climate (MacIver et. al., 1994).

Short rotation tree plantations are often low-diversity systems dominated by non-native species. While carbon update is high (due to rapid initial growth rates), other environmental impacts are negative. Single plantation low diversity systems may be less tolerant and adaptable to rapid climatic change. We may now need to begin asking if single species plantations forestry is still a viable method of forestry in the future? Protecting natural forests have other important benefits such as preserving biodiversity, which have a greater long-term ability to sequester carbon. It is expected that biodiversity will increase under global warming. In reality invasive species, planned or otherwise, will take advantage of future favourable atmospheric conditions, normally at the expense of native and indigenous species. Increasing extinctions and maladaptations can be expected to occur throughout Ontario (MacIver et. al., 1994).

Analytical Model

The diversity curves are a rapid assessment tool that can be used in the field. At the present time, based on the observed measurements and field checks, there is a reasonable level of confidence that the community, with basic training in monitoring, can identify trees to the genus level and are able to provide accurate diameter measurements at breast height. A second generation of trained monitors will be necessary for measuring tree height, volume, carbon sequestration and tree health.

The Diversity Curves technique gives greater weighting to more abundant species. It allows us to consider all species and to not focus solely on the rare ones. Species are usually the best category of biodiversity response variables. Measuring genetic diversity would be ideal, but too expensive for the volunteer community. Other entities such as habitat or vegetation classes have an element of arbitrariness that may confuse analysis (Science Findings, 2000). Species frequently show complementary distributions (different species occur in different regions) meaning that prioritising areas to monitor can be quite effective. The hierarchical approach can integrate biodiversity conservation planning from local to regional and national levels. One hierarchical, objective approach to conserving biodiversity is based on prioritising sets of species rather than focusing on individual species or whole ecosystems. This method has already been somewhat successful (Science Findings, 2000).

Size Dependency

Preliminary results on the size dependency issue are interesting. In Backus Woods, if we were to sample only one 20 x 20 metre quadrat we would find an average of two families (ranging from a minimum of 1 to a maximum of 5). Sampling two 20 x 20 quadrats result in an average of five families (range 3 - 7), sampling three quadrats result in an average of six families (range 4 - 8) and sampling five quadrats result in an average of nine families (range 6 - 11). Over the 25 quadrats (1 hectare) we actually found 11 families represented, with at least five trees per family. Even if the cut-off number of trees was reduced to 4, 3, 2 or 1 trees per family (presence/absence) this still result in a relatively low number of potential species represented - an average of 3, 5, 6 and 9 families respectively. This then suggests that forestry plots, which may range in size from a 20 x 20 metre plot to a 40 x 20 metre plot for example could potentially under represent the number of families on a site. As growth and yield plots, they meet their purpose extremely well but as biodiversity plots they may not be capturing the number of families on the site because of the

size dependency nature of biodiversity. Backus Woods and the CARE plot were compared to some data from England where it was shown that maximum diversity for minimum area occurs around the 1 ha size unit (Figure 9). With the 25 quadrats in Backus Woods, we are very close to the peak of the curve, indicating that around this sample size area there was a maximum number of species for a minimum amount of area. Fewer quadrats result in what appears to be significantly less number of species groups. The CARE plot, with fewer numbers of families, peaks in the same location but its maximum value is less than the more diverse plot at Backus. This suggests that there may be a family of related curves. Species diversity appears to increase with increasing area sampled (up to a certain area).

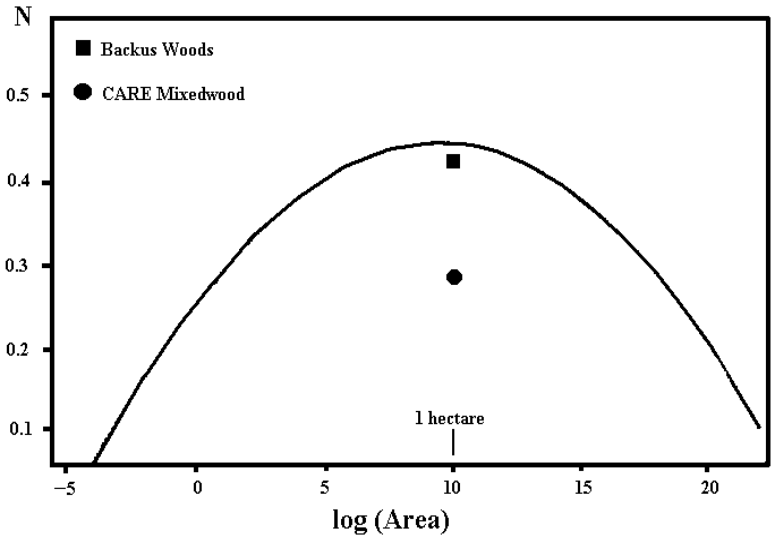

Figure 9. Dependence of number of families sampled with respect to plot size.

The two plots at Charlevoix provide another example of the size dependency relationship. This site is primarily pure black spruce. One family was found at the one 20 x 20 metre quadrat size and two families were found after sampling all twenty-five 20 x 20 metre quadrats. In the single species forest there is much less dependency on the number of quadrats than in more diverse forests. This supports the recommendation that five 20 x 20 metre quadrats may be sufficient in stands where there are only one or two species (Roberts-Pichette & Gillespie, 1999).

The western red cedar at Galiano was another example of the relationship between the number of quadrats and the number of families. Five families per hectare were identified with all 25 quadrats measured and only two families/ha were identified with five quadrats measured at an adjacent plot.

Importance of On-going Monitoring and Assessment

Monitoring for biodiversity has three main stages. The majority of Canadian plots are in Stage One but over the next few years, selected sites that are four years or older may be entering into stage two. Stage One is the initial assessment of what is there, recording all plants and animals and noting their size, condition, location, and numbers. This baseline information (distribution and abundance of the species) allows for immediate comparisons and case studies.

Stage Two is the successive visits recording what is there, looking for changes and determining what is causing those changes so as to compile a complete picture of the environments and how it functions and then linking that information to society. Detailed biodiversity assessments provide the basic information to discovering the intricate links among species. A well-established biodiversity baseline allows the selection of indicator species for long-term monitoring (Alonso and Dallmeier, 2000). Monitoring provides early detection for invasives and disease and is very important in identifying bio-climate changes. Only a 1-2 degree change in average global temperature can affect the distribution and abundance of tree species, so we need to know how tree species composition is changing.

In Stage Three, once a baseline is established, continuous monitoring will indicate whether or not the populations are shifting and what changes if any to the natural system have occurred. The focus is on determining how those changes came about and the extent to which they may be detrimental to the natural

system and its resources. There is a need to decide what can be done to lessen harmful impacts and to provide better choices for society (Alonso and Dallmeier, 2000).

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Table 1. Baseline tree information collected from Canadian and International forest monitoring plots.
Table 2. Distribution of number of stems by Family for 37 forest monitoring plots.

APPENDIX A SAMPLE SITE PROFILES

Atlantic Maritime Ecological Science Cooperative

Fundy National Park
Number of plots: 5
Established: 1996-1998
Contact: Renee Wissink – Park Ecologist
Purpose: Research, Conservation

The five plots have been established in a variety of areas at Fundy National Park: hardwood forest, alder swamp, old mix forest and old coastal softwood. There is evidence that selective harvesting was conducted previously in three of the five plot areas. Two of the five areas were impacted by a spruce budworm infestation.

The plots were established by Parks Canada and students in order to collect baseline inventory data on the biodiversity within each plot. To date, only portions of each plot have been inventoried.

Kejimikujik National Park
Number of plots: 5
Established: 1994 (plot 1, plot 2, plot 3 - 4 quadrats, plot 4 - 4quadrats) , 1997 (plot 5)
Contact: Sally O'Grady – Information Management Specialist & Cliff Drysdale – Ecosystem Science Manager
Purpose: Training, Research

Kejimkujik National Park is representative of the Atlantic Coastal Uplands Natural Region of Nova Scotia, covering an area of 381 km^2. Kejimkujik National Park, established in 1974, typifies the glaciated, rolling drumlin topography of southwestern Nova Scotia, interspersed with lakes and streams. The area has been used by the Mi'kmaq peoples for 4500 years. The Mi'kmaq travelled the inland waterways from the Fundy Coast to the Atlantic Coast.

Plot 1, Kejimkujik National Park.

Plot 1 is adjacent to Grafton Brook, which is located at the end of the main park road, approximately 10 km from the front entrance. The area was primarily harvested for white pine and red oak.

Plot 2 is approximately 200 metre north of Grafton Lake, located at the end of the main park road. Plots 1 and 2 are paired with Plot 3 (four quadrats) and Plot 4 (four quadrats) respectively (all established in 1994). These plots are used 1) as an experiment to evaluate the SI/MAB plot protocol for multi-taxa monitoring and 2) to monitor the impact of long range transport of air pollutants on Nova Scotia Acadian forest ecology. Tree inventory data was collected initially in 1994 and again in 1999. Additional inventories have been done on ground vegetation, arthropods (Forest Lepidoptera, Forest Insect and Disease Survey, Myriapods and Collembola, Gypsy Moth, mites), Basidiomycete Fungi and terrestrial molluscs.

Plot 5 was established in 1997 and is located south of Canning Road, along the boundary in Kejimkujik National Park, approximately 7 km from the park entrance. The primary purpose of this plot is to acquire base line data for long term monitoring and evaluation of changes in a mixed softwood hemlock forest. It

was designed to be a control site for comparative forest bird monitoring within a protected area and the working landscape to evaluate changes in biodiversity.

All of the plots at Kejimkujik National Park have been used as training sites, focusing on teaching participants how to establish a plot, as well as how to carry out site assessments for a variety of abiotic and biotic components. Plot 1 & 2 were the first SI/MAB Forest Monitoring Plot established in Canada (1994). A variety of representatives from government agencies and local forest companies have participated in these training sessions.

Plot 2, Kejimkujik National Park.

Kejimkujik National Park Joint Ventures
Number of Plots: 5
Established: 1996-1999
Contact: Sally O'Grady – Information Management Specialist & Cliff Drysdale – Ecosystem Science Manager
Purpose: Impact Assessment, Research

Several monitoring plots have been established outside Kejimkujik Naitonal Park through cooperative efforts with private companies and provincial parks. In most cases, students and adult trainees were used to collect data in these monitoring plots.

The Bowater Mersey Paper Company installed a plot in 1997 in order to evaluate sylviculture techniques and the role of forest gaps in red spruce regeneration. This plot was set up due to the concern expressed by the Canadian Forest Service that red spruce appears to be under stress in eastern North America. This study has been carried out by Dr. Liette Vasseur of St. Mary's University and has subsequently received NSERC funding. Concurrently, forest bird monitoring was implemented by Dr. Cindy Staicer, of Dalhousie, to assess the effects of different harvest techniques on population and biodiversity status.

The NF Douglas Lumber Company set up one full plot and eight replicate quadrats in 1996. The study plot and associated replicate quadrats were installed to evaluate sylviculture techniques to support managed white pine regeneration in a mixed forest environment. Concurrently, forest bird monitoring was implemented to assess the effects of different harvest techniques on population and biodiversity status.

Harry Freeman and Sons Lumber Company installed a monitoring plot in 1998 to test the effects of liming on the survival and growth of softwood species. No experimental work has been done to date.

Finally, a plot was established in T. H. Randall Provincial Park in 1999 in order to document the biodiversity and growth of tree species in a coastal environment.

Boreal Cordillera Ecological Science Cooperative

Wolf Creek
Number of plots: 2
Established: 1997
Contact: Joan Eamer – Head of Ecosystem Health, Environment Canada
Purpose: Research and Education
Website: http://taiga.net/wolfcreek

Measuring tree height at Wolf Creek.

The plots are located 15km south of Whitehorse in relatively pristine forest; one of the plots contains trees dating back to the 1700s. Several fires have damaged trees (most recent fire was 1950); there is no evidence of heavy insect infestation and no logging has occurred in this area. Windthrow is a significant process for the mature white spruce plot. Tree species include white spruce, lodgepole pine, balsalm poplar and several willow species.

The plots were established to 1) track change in the Boreal Cordillera forest ecosystem, 2) develop an inventory of species and habitats and 3) establish a framework for integrated research. The plots are part of a larger, long-term multidisciplinary research project in the Wolf Creek drainage basin where current research activities include: climate and climate change, vegetation, forestry, fisheries and wildlife. There are three climate stations in the basin. Future monitoring programmes being planned or considered for the plots are: forest ground vegetation, fungi, insects (density and diversity in relation to canopy structure), spiders, and leaf and log decay. Past and present monitoring programmes are: breeding bird surveys, soil fungi survey, tree coring for fire/insect history, vegetation species inventory.

Yukon Youth Conservation Corps and Yukon College students have been taught basic forest surveying skills and scientific study methods as part of their participation in plot monitoring. They were also introduced to the issues of climate change and biodiversity conservation as part of the programme. The plots are to be re-evaluated five years after esablishment.

Boreal Plains Ecological Science Cooperative

Riding Mountain National Park
Number of plots: 2
Established: 1997, 1998
Contact: Wybo Vanderschuit
Purpose: Emerging Issues, Impact Assessment; Management, Research

The first plot was established in an area of eastern deciduous forest in Riding Mountain National Park. The site is subjected to annual spring flooding and the presence of Dutch Elm disease was discovered in 1981. Various monitoring protocols have been used (SI/MAB tree mapping, EMAN Shrub and Ground Vegetation Mapping and EMAN/CFS Tree Health) to assess the impact of Dutch Elm disease on *Ulmus americana* and stand

Eastern deciduous forest, Riding Mountain National Park.

composition. Plot reassessments are scheduled for 2002 and 2007.

The second plot was established in an area of Bur Oak (also known as Blue Oak) to monitor restoration of a grassland community resulting from a prescribed burn. SI/MAB and EMAN protocols have been used for data collection; baseline data on ecological restoration has been completed. Future research in the plot may also involve the monitoring of rare and endangered species.

Boreal Shield (Newfoundland and Labrador) Ecological Science Cooperative

Climate station at Blue Hill.

Terra Nova National Park
Number of plots: 1
Established: 1999
Contact: Peter Deering
Purpose: Research, Emerging Issues

The Blue Hill West area of Terra Nova National Park is representative of the park's aging forest and is showing signs of breaking up. The plot was established in order to monitor long term successional trends in the black spruce-balsam fir forest. Seed rain/germination and forest canopy gap analyses are planned for the next few years.

Plot measurements were carried out by the Conservation Corps of Newfoundland and Labrador Green Team.

Boreal Shield (Québec) Ecological Science Cooperative

Charlevoix Biosphere Reserve
Number of plots: 1
Established: 1999
Contact: Charles Roberge
Purpose: Education, Research

The plot in the Charlevoix Biosphere Reserve was established in conjunction with the tenets of the biosphere reserve, that of "in situ" research and education. It is located 120 km north-east of Québec City at an altitude of 800 to 900 metre in the Laurentide massif. The area is representative of the majority of the park, composed primarily of boreal forest (black spruce, tamarack, balsam fir and white birch) with some alpine components.

It is hoped that students from the Charlevoix area will be able to participate in future forest inventories.

La Mauricie
Number of plots: 1
Established: 1996
Contact: Albert van Dijk, Chef, Conservation des ressources
Purpose: Research, Conservation

The plot is located in about 1100 hectares of boreal forest composed mainly of black and red spruce varieties, typical of about one third of the park. The black spruce comprise 60-80% of the density and have an average age of 70 years. The area was burned in 1925 and was heavily colonized by white pines. There has been no human intervention since the park's creation in 1970.

The plot was established primarily to document forest population dynamics on a long-term basis by integrating with existing external (national and international) monitoring programmes. Future plots may be installed in the area over the next few years.

A group of forestry students from CÉGEP de la Gaspèsie assisted in the establishment of this and other plots across Quebec in the fall of 1996.

Saint-Hippolyte
Number of plots: 1
Established: 1996
Contact: Hendrik van Leeuwen – Station de biologique des Laurentides, Université de Montreal
Purpose: Research, Emerging Issues

Located in the southern Lauentians in an area dominated by maple, beech and yellow birch, the plot was established within a first-order catchment (approx. 0.06 km^2) where a number of researchers have been investigating the effects of short term climatic variations on nutrient cycling and forest growth (air and soil temperature, stream flow, watertable height, soil moisture content, water chemistry, soil chemistry, tree chemistry, and tree and root growth).

The plot was established by the Station de biologique des Laurentides to provide and promote an environment that encourages education and research opportunities in forest ecosystems. By using the SI/MAB standardized protocols and thus providing the opportunity to couple data from Saint-Hippolyte with other SI/MAB data, a greater understanding of the relationship between ecosystem structure and function can be obtained.

Grand Council of Crees
Number of plots: 3
Established: 1997
Purpose: Education, Training
Website: http://www.gcc.ca

Three plots were established in the boreal forest of northern Québec near the communities of Waswanipi, Mistissini and Ouje-Bougoumou. The original intent was to provide an educational opportunity for Cree youth to become familiar with scientific methodologies and conservation theories. Of the three plots, Ouje-Bougoumou and Waswanipi were fully surveyed and tagged. These plots have yet to be certified for accuracy. Conditions in the boreal forests of northern Québec made it difficult to establish these plots. For example, in Ouje-Bougoumou there were over 4000 mature trees per hectare in the plots, which was too demanding for a student-based approach. No further work has been done on these plots and no work is planned.

Waswanipi, student with rangefinder.

Boreal Shield (Ontario) Ecological Science Cooperative

Experimental Lakes Area
Number of plots: 2
Established: 1997, 1998
Contact: John Shearer – Senior Biologist and Operations Manager
Purpose: Education and Research
Website: http://www.umanitoba.ca/institutes/fisheries

The plots are located in unsurveyed territory approximately 53 km east south-east of Kenora, Ontario, near the Experimental Lakes Area field station. The first plot was established in a regenerating jack pine stand, which was naturally seeded following a wildfire in 1980. Prior to the fire, the site was covered with mature, +100 year old boreal forest. The second plot was established along a ridge to the west of ELA Lake 302. No harvesting has been conducted on this site and the last wildfire was estimated to have occurred at least 80 years ago. A broad range of meteorological and hydrological data has been monitored in and around the ELA since 1969.

Dryden High School students assisted in the establishment of both plots, learning about forest ecology and forest inventory techniques. Because of the nature of the young, regenerating Jack Pine stand (thousands of stems per hectare) in Plot 1, SI/MAB protocol was not strictly adhered to (only five of the quadrats were surveyed). Plots are to be resurveyed every 5 years.

Plot at Lake 302.

Mixedwood Plains Ecological Science Cooperative

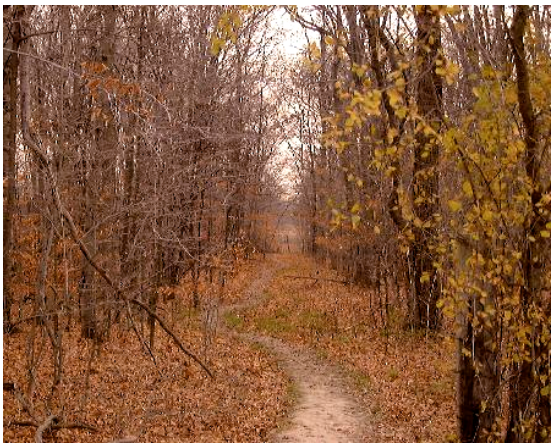
Long Point Biosphere Reserve
Number of Plots: 4
Established: 1995, 1996
Contact: Brian Craig – Network Science Advisor, EMAN
Purpose: Education, Conservation
Website: http://www.kwic.com/~longpointbio/

Students at LPBR.

The four plots are located in three areas of the Long Point Biosphere Reserve (LPBR): Backus Woods, an old growth Carolinian forest composed primarily of oak and maple species; Wilson Tract, a managed Carolinian forest which has been subjected to periodic timber extraction; and Turkey Point Provincial Park, with plots in disturbed and natural Oak Parkland. In addition to tree, shrub and ground vegetation inventories, data on salamanders, soil health and aquatic invertebrates (mayflies and caddis flies) has been collected.

Local students (elementary and high school) and volunteers have been instrumental in data collection becoming familiar with the various SI/MAB protocols, research methods and environmental ethics. A number of students who have participated in the Long Point Student Monitoring Camp have assisted in writing reports on the plots, have given presentations at conferences and are now pursuing careers in science and environmental studies.

Brock University/Short Hills Provincial Park
Number of plots: 2
Established: 1999, expected early 2001
Contact: John Middleton – Centre for the Environment, Brock University
Purpose: Education, Conservation
Website: http://www.brocku.ca/envi/simab/



Plot at Brock University Campus.

Both plots are located within the Niagara Escarpment Biosphere Reserve in the Regional Municipality of Niagara. The areas were used originally as farm woodlots.

The first plot is on the Brock University campus and is heavily used by Brock biology and environment classes. It is designed to be used in conjunction with the second plot at Short Hills which will be protected from heavy use by students. So far, the ecology, conservation planning and tourism students who have already participated have given enthusiastic responses. Emphasis will be on comparing data collected among plots and years, initially between the Brock and Short Hills plots but expanding to include data collected from plots in other parts of the country and beyond, once they are readily available.

Royal Botanical Gardens
Number of plots: 2
Established: 1997
Contact: Carl Rothfels, field botanist
Purpose: Education, Training
Website: http://www.rbg.ca

The first Royal Botanical Gardens (RBG) plot is located in the Rock Chapel Nature Sanctuary, south of the Armstrong nature trail on the Niagara Escarpment. The area has been a nature sanctuary since the 1950s or 1960s. Prior to that, the area may have been logged, with evidence of an old cart track near the site. The second plot is located in the Borer's Creek Conservation Authority. It lies on a river terrace on the west side of Borer's Creek.

The first plot is located in an area composed predominantly of sugar maple. The second plot, at Borer's Falls, has an abundance of black maple as well as the occasional black walnut. The shape of the plot at Borer's Falls had to be slightly adjusted (60m wide by 200m long) as it boarders a creek. Summer students (university graduates) and outdoor education students from a local high school have collected most of the data. Ideally, it will continue to be used for educational purposes.

Toronto Island
Number of plots: 2
Contact: Brian Craig – Network Science Advisor, EMAN
Established: 2000, 2001
Purpose: Education

In conjunction with visiting students from Northwestern University in Chicago, Illinois, the Ecological Monitoring and Assessment Network Coordinating Office established a full 1-ha plot in 2000 and a series of six quadrats during the spring of 2001.

The site serves as an educational tool for school groups participating in the Toronto Island Outdoor Education School programmes.

Joker's Hill
Number of plots: 1
Established: 1997
Contact: Terry Carleton – Botany Department, University of Toronto

Purpose: Research, Education

The study area is on an estate of approximately 600 hectares near Newmarket. The plot was established as part of a University of Toronto botany course (JBS229S) requirement. Students were required to survey the plot, according to SI/MAB protocol, and to perform relevant statistical analyses (distributions of tree height and tree diameter, spatial distribution, tree density and volume).

Tiffin Centre for Conservation (Nottawasaga Conservation Authority)
Number of plots: 2
Established: 1997, 2001
Contact: Byron Wesson, Director of Conservation Services
Purpose: Research, Education, Training

The Nottawasaga Conservation area consists of welands, forests, meadows, ancent lake beds, glacial shorlines, uplands and valleys.

The first plot at the Tiffin Centre for Conservation in Angus, Ontario, was established in conjunction with the University of Toronto (Botany course JBS229). As with the plot established at Joker's Hill, students were required to collect tree inventory data and to perform relevant statistical analyses.

A second plot site has also been established and data collection is scheduled to commence in the summer of 2001. This plot will be used primarily for elementary and high school students to meet the natural resources and interactions within ecosystems components of their curriculum.

Mono cliffs outdoor Education Centre & Association for Canadian Educational Resources (ACER)
Number of plots: 1
Established: 1997-1998
Contact: Kathy Lindsay – Outdoor Education Specialist
Purpose: Education
Website: http://www.acer-acre.org

Over the course of the past five years, the Association for Canadian Educational Resources (ACER) has been active in establishing community-based forest inventory plots throughout the southern Ontario area in conjunction with various Education Centres.

A one hectare plot was established at the Mono Cliffs Outdoor Education Centre in a grazed hardwood forest. Student groups did data collection in this plot and the use of environmental monitoring as an educational tool continues.

Boyne River Natural Science School & ACER
Number of plots: 1
Established: 1996-1997
Contact: Norm Frost - Site Supervisor
Purpose: Education
Website: http://www.acer-acre.org

In cooperation with ACER, the Boyne River Natural Science School has established a one hecare plot on site. The Boyne monitoring plot is set in an area mainly consisting of maple-beach climax forest, meadows and wetlands. Data collection in this plot has been initiated by the site supervisor at the Boyne River Natural Science School with the help of secondary school students.

Wiarton Outdoor Education Centre & ACER
Number of plots: 1
Established: 1996-1998

Contact: Debbie Diebel - Outdoor Education Specialist
Purpose: Education
Website: http://www.acer-acre.org

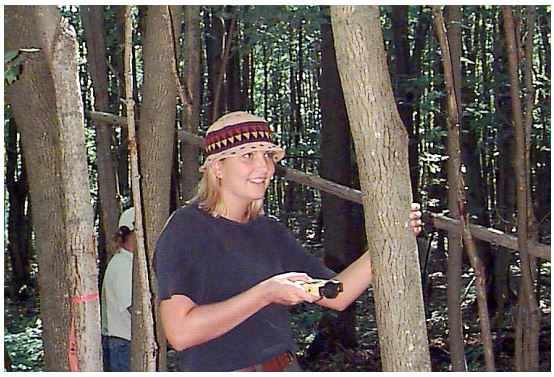
In conjunction with ACER and the Bruce Country Board of Education, the Wiarton Outdoor Education Centre has established a community-based inventory plot. The Wiarton plot is in a hardwood forest area on the centre's property. Students and teachers have helped in the data collection on site and there are plans to continue with this programme as an educational tool.

Sky Lake plot, Bruce-Grey county Board of Education.

Niagara Escarpment Commission / Ontario's Niagara Escarpment Monitoring Programme
Number of plots: 5
Established: 1996-2000
Contact: Anne Marie Braid, Ecological monitoring specialist
Purpose: Impact Assessment, Education, Training
Website: http://www.escarpment.org/Monitoring/onemonitoring.htm

Five plots have been established in various areas along the Niagara Escarpment.

Hilton Falls is a transitional zone between the Carolinian Region and the Southern Deciduous-Coniferous Forest Region which remained relatively undisturbed during human settlement (poor soil for cultivation). Conifer plantations and road construction as well as recreational use (Bruce Trail) and selective logging have impacted the area.



Cabot Head plot.

Hockley Valley is a large, contiguous forest block that stretches for 16 km north-east of Orangeville. Approximately 80% of the Valley was cleared of mature trees by the late 1900s. Many of these areas were later reforested. The western end of the Valley is designated a Class 1 "Strict Nature Reserve/Scientific Reserve" by the International Union for Conservation of Nature.

Cabot Head was used as a logging and mill site in the late 1800 and early 1900s. There is a trail adjacent to the plot, most likely a logging tote road to take logs away from the bush to Wingfield Basin. Cabot Head is also designated as a Class 1 Nature Reserve.

A sizeable portion of the Hope Bay Forest Area of Natural and Scientific Interest (ANSI) is intermediate to semi-mature in age and is gradually approaching an older, undisturbed condition. Several land-use impacts noted within the ANSI include: selective logging, light to moderate grazing, logging roads and light use of trails.

The fifth plot, in the Skinner's Bluff Management Area, is located in Grey County. The escarpment plain was selectively logged 20 to 30 years ago and is situated near a little used portion of the Bruce Trail.

The plots were set up for long-term monitoring and it is hoped that comparisons of monitoring variables (e.g. native floristic quality, species richness, biomass, canopy height, etc.) can be made between "control" plots and "pressure" plots (that are subjected to higher rates of human disturbance). Because the

monitoring of sites will occur over the long term, it will help increase understanding of forest dynamics and ecosystem processes that can be used to assess the impact of disturbance and predict change. SI/MAB plot monitoring on the Escarpment is part of a larger monitoring programme (Ontario's Niagara Escarpment Monitoring Programme), which was established to determine whether the policies of the Niagara Escarpment Plan (Canada's first large-scale environmental land use plan) are adequate to protect the Niagara Escarpment.

A variety of site reports (describing the areas) and resource materials (background information on monitoring, data analysis, protocol reference manual) have been written with respect to these plots.

Mont St.-Hilaire
Number of plots: 2
Established: 1996, 1997
Contact: Martin Lechowicz – Director of Environmental Studies, McGill University
Purpose: Research, Impact Assessment
Website: http://www.mcgill.ca/gault/

Prior to the devastating ice storm in 1998, two plots were established in the Mont St.-Hilaire Biosphere Reserve at Lake Hill and Botany Bay. Originally established to study long-term forest dynamics in an area of old growth forest uncut since European colonization, the plots now serve as study sites for monitoring the recovery and mortality of trees affected by the ice storm. A number of publications have been and continue to be produced from the research done at these sites.

Overhead view of Mont St. Hilaire Biosphere Reserve.

Montane Cordillera Ecological Science Cooperative

Yoho National Park
Number of plots: 4
Established: 1995
Contact: Derek Peterson
Purpose: Research, Education, Training

Aspen plot, Yoho National Park.

The plots at Yoho National Park are representative of two different forest types in the area: aspen and conifer. Although the plots are in close proximity to areas of high human activity, they are considered representative of undisturbed aspen and conifer zones within the park.

Primarily, the plots provide a pre-established area for the collection of a diverse range of baseline biodiversity data. Subsequent information collected on aspen and conifer mortality and regeneration will help to illustrate the dynamic structures of the respective forest systems.

The conifer forest monitoring plots have also been used to train and educate interested high school and college students in tree species identification and forest conservation. Many of the volunteers participated through the Young Canada Works summer students programme and through the Research Adventure programme (visitors pay to participate in field research activities).

Pacific Maritime Ecological Science Cooperative

Rocky Point
Number of plots: 2
Established: 1995
Contact: Arthur Robinson, Natural Resources Canada
Purpose: Research

The plots are located on Department of National Defence Lands west of Victoria, British Columbia.

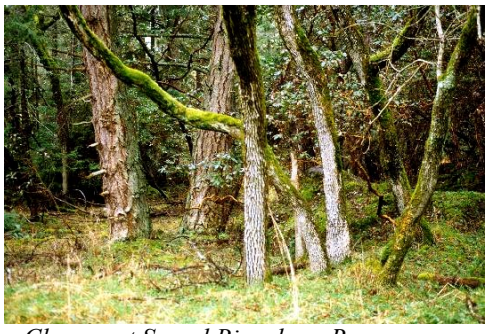
The first plot is in an old-growth Douglas-fir-Salal forest community. Old growth Douglas-fir is a rare ecosystem on Vancouver Island. The plot area has been used for amphibian and snake monitoring, invertebrate inventories and dendrological studies.

Rocky Point.

The second plot is located in an area characterized by deep-soil Garry oak woodland community. Additional studies (such as an invertebrate inventory, and a Stellar's Jay/Garry oak seed dispersal study have been done in the area.

The establishment of both plots was in response to Canada's Biodiversity Strategy's Goal #2: "To improve our understanding of ecosystems and increase our resource management capability" with the enhancement of biological inventory efforts in threatened ecosystems. The plots provided a training function as students from University of Victoria and the Lester B. Pearson College of the Pacific assisted with the plot inventory.

Clayoquot Sound Biosphere Reserve
Number of plots: 1
Established: 1995
Contact: Thomas Esakin
Purpose: Research, Conservation


Clayoquot Sound Biosphere Reserve.

This area of the Clayoquot Sound Biosphere Reserve is an undisturbed west coast temperate rainforest; the floodplain of the Clayoquot River. The plot is characterized by large diameter sitka spruce (>1m dbh), red alder and gravel bars which extend 150m away from the Clayoquot River. The Clayoquot plot indicates the dynamic nature of alluvial rainforest ecosystems and the importance of establishment of riparian buffers along west coast streams.

The plot will be used as a baseline for long-term monitoring of changes in tree composition and of tree growth, particularly as these relate to succession patterns in an undisturbed alluvial forest. An inventory of the trees in the plot was completed in 1997 (the inventory began in 1995 but was halted due to severe flooding). Observations on amphibians, fish, bats, mammals and birds (including Marbled Murrelets) have also been documented in the area through the Ministry of Environment's wildlife inventory programme and Long Beach Model Forest research.

Mount Arrowsmith Biosphere Foundation
Number of plots: 1
Established: 1998
Contact: Glen Janieson
Purpose: Research, Training

The plot is located at Englishman River Falls Provincial Park, 13 km southwest of Parksville British Columbia, in the Mount Arrowsmith Biosphere Reserve. The area was subjected to logging approximately 100 years ago.

Long term monitoring will provide baseline data from a relatively undisturbed area in one of the biosphere reserve's biogeoclimatic zones. Long term monitoring will be required to determine the effects of environmental changes on ecological communities that may result from pressures such as population growth or from other factors such as global warming. To date, the majority of the information collected has been from tree inventories with further inventories of vegetation and fauna planned.

A student exchange has been established between the Mount Arrowsmith Biosphere Foundation and the Long Point Biosphere Reserve to promote education and training.

Royal Roads University/Hatley Park
Number of plots: 2
Established: 1996
Contact: Bill Dushenko – Applied Research Division & Nancy Kwong – Applied Research Division
Purpose: Education/Impact Assessment, Training/Research
Website: http://www.royalroads.ca/Channels/

Hatley Park plot #2.

The plots have been established in the outlying forest of the Royal Roads/Hatley Park property to, in part, monitor the effects of increased urban encroachment and disturbance. Recommendations regarding the effective long-term management of these impacts will be made from studies examining biological diversity and ecosystem structure/function at the forest system edge. The two plots include an upland old field and mixed western red cedar ecosystem transition zone, and a salt marsh/estuary and mixed Douglas-fir ecosystem transition zone, respectively. To date, studies of tree, shrub, coarse woody debris, ground cover, soil moisture analysis and organic content, worms, and terrestrial gastropods have been made.

Originally, portions of one of the plots were used as a cattle-grazing pasture. Given the agricultural historical usage, there is an easily accessible road that runs through the plot between the two ecosystems.

A number of university and grade school students, scout troops, EMAN tour groups and the general public have participated in tree and ground surveys. These groups were provided with the opportunity to learn about biodiversity, invasive exotic species, human impacts and associated climate change.

A third plot is being established in the forest interior as a basis for comparison with studies occurring at the edges. As well, expansion of the studies into other emerging issues such as monitoring climate change and atmospheric contaminant effects/adaptations are currently being planned for the plots.

Galiano Conservancy Association
Number of plots: 1
Established: 1999
Contact: Ken Millard, Coordinator
Purpose: Conservation, Education

The Gulf Islands are part of the coastal Douglas-fir biogeoclimatic zone, which is designated as an "Ecosystem at Risk" by the British Columbia Conservation Data Centre. The Pebble Beach Reserve (322 acres) encompasses three parcels of land: the central one owned by the Galiano Conservancy (1998), and a Crown Land parcel on either side. The area is ecologically significant, home to many diverse and healthy ecosystems: a freshwater lake and creek, remnant old-growth coastal Douglas-fir forest, naturally regenerated forest and a healthy, younger Douglas fir plantation. While this plot has been established in a naturally regenerated forest, there is the potential to establish comparison plots in plantation and old-growth forests.

Galiano Island, Pebble Beach plot.

Prairies Ecological Science Cooperative

Delta Marsh Field Station
Number of plots: 2
Established: 1999
Contact: Gordon Goldsborough – Director
Purpose: Conservation, Training
Website: http://www.umanitoba.ca/faculties/science/delta_marsh

This site is one of the few remaining "gallery" forests in Manitoba, near the western-most extent of oak trees in Canada. The forest is situated in an oxbow of a paleochannel of the Assiniboine River (near Portage la Prairie), at least 2000 years old. The site has seen limited human activity and has never been logged or farmed. It is as close to a pristine, pre-settlement forest as likely exists in southern Manitoba. The site has been protected within University of Manitoba property since 1966 and was designated as an Ecologically Significant Area in 1987 by the Province of Manitoba.

Oxbow Woods.

Both plots were surveyed by university students using the EMAN Terrestrial Vegetation Monitoring Protocols.

Taiga Plains Ecological Science Cooperative

Gwich'in Renewable Resource Board
Number of plots: 1
Established: 1998
Contact: Jennifer Walker-Larsen – Forestry/Fisheries Biologist
Purpose: Training, Education
Website: http://www.grrb.nt.ca

The plot was established south of Inuvik in the Mackenzie River Delta. The delta is used for subsistence by the Gwich'in. Gwich'in beneficiaries cut wood for firewood and lumber, fish, and hunt geese and muskrat in the area. Near the plot are several abandoned Gwich'in camps.

Students from the Aurora College Natural Resources and Technology programme helped establish the plot. Junior high and high school students participate in surveying the plots. Census techniques, tree mapping, tree identification and aspects of forest ecology are among the concepts presented to the students.

Training session, Gwich'in Renewable Resources Board.

APPENDIX B LIST OF CURRENTLY KNOWN SI/MAB SITES ACROSS CANADA

Ecozone	Site	Plot(s)
Atlantic Maritime	Prince Edward Island	Plot #1 Plot #2
	Fundy National Park	Alder Swamp Hardwood Forest Old Coastal Softwood Old Mix Forest (W. boundary) Old Mix Foest (Wolfe Lake)
	Kejimkujik National Park	Plots 1 – 5 Bowater Plot Blair Douglas Plot Harry Freeman Plot T. H. Randall Provincial Park Plot
Boreal Cordillera	Wolf Creek	Plot #1 Plot #2
Boreal Plains	Riding Mountain National Park	Eastern Deciduous Bur Oak
Boreal Shield (NF & LAB)	Terra Nova National Park	Blue Hill West
Boreal Sheild (Québec)	Charlevoix Biosphere Reserve	Parc des Jardin (GJ199) Parc des Jardin (GJ299)
	La Mauricie	La Mauricie
	Forillon	
	Grosse Ile	
	Mingan Archipelago	
	Station Biologique des Laurentides	St Hippolyte, Hermine
	Grand Council of Crees	Ouje-Bougoumou Mistissini Waswanipi
Boreal Shield (Ontario)	Experimental Lakes Area	Lake 302 Rawson Lake
Hudson Plains	Churchill Northern Studies Centre	Plot 1 Plot 2

Mixedwood Plains	CARE (Centre for Atmospheric Research Experiments)	Mixed Red Pine
	Long Point Biosphere Reserve	Backus Woods Wilson Tract Turkey Point 1 Turkey Point 2
	Bruce Peninsula National Park	
	Brock University	Brock Campus Short Hills Provincial Park
	Royal Botanical Gardens	Rock Chapel
	Hamilton Naturalists' Club	Borer's Falls Shorthills
	Tiffin Centre for Conservation	University of Toronto Tiffin
	Niagara Escarpment Commission	Cabot Head Hilton Falls Hockley Valley Hope Bay Skinner's Bluff
	Palgrave	
	Boyne River Ministry of Natural Resources	
	Boyne River Natural Science School	
	Albion Hills	
	Richardson Estate Plot	
	Dufferin County	Mulmur Township Mono Township
	Toronto Island	
	Scarborough Cemetary	
	Humber Arboretum	Plot 1 Plot 2
	University of Toronto	Joker's Hill
	Kortright Conservation Centre	
	Trent University Wiarton	
	Metro Toronto Zoo	Landon Bay
	Gananoque	Botany Bay
	Mont St. Hilaire	Lake Hill
Montane Cordillera	Waterton National Park	Forest Grassland
	Yoho National Park	Aspen Mixed Conifer

Pacific Maritime	Rocky Point	Douglas Fir Garry Oak
	Clayoquot Mount Arrowsmith Biosphere Reserve Royal Roads University	Clayoquot River Hatley Park, Lagoon Plot Hatley Park, Upland Plot Pebble Beach
	Galiano Conservation Association	Greig Creek
	UBC Forest Plot Lower Seymore Conservation Reserve	
Prairies	Delta Marsh Field Station	Oxbow Woods
Taiga Plains	Gwich'in Renewable Resources Board	Gwich'in Territorial Park

APPENDIX C GLOSSARY

ACER – Association for Canadian Educational Resources

BioMon – software developed for SI/MAB Forest biodiversity plot monitoring to store and summarize large amounts of vegetation information.

CARE – Centre for Atmospheric Experiments

CFS – Canadian Forest Service

Dbh – Diameter at breast height

EMAN – Ecological Monitoring and Assessment Network

EMAN CO – Ecological Monitoring and Assessment Network Coordinating Office

EMP – Ecological Monitoring Protocols

ENGO – Environmental Non-Governmental Organizations

GDD – Growing degree days

GLP – Growth Layer Profiles

KNP – Kejimkujik National Park

NEBRS – Niagara Escarpment Biosphere Reserve System

NGO – Non-Governmental Organization

NSERC – National Science and Engineering Research Council

ONE – Ontario's Niagara Escarpment

SI/MAB – Smithsonian Institute Man and Biosphere, now known as the Smithsonian Institute Monitoring and Assessment of Biodiversity programme