3 BIODIVERSITY

The distribution of biodiversity in Canada is determined to a great extent by climate. Figure 42 shows one representation of current biodiversity in Canada.

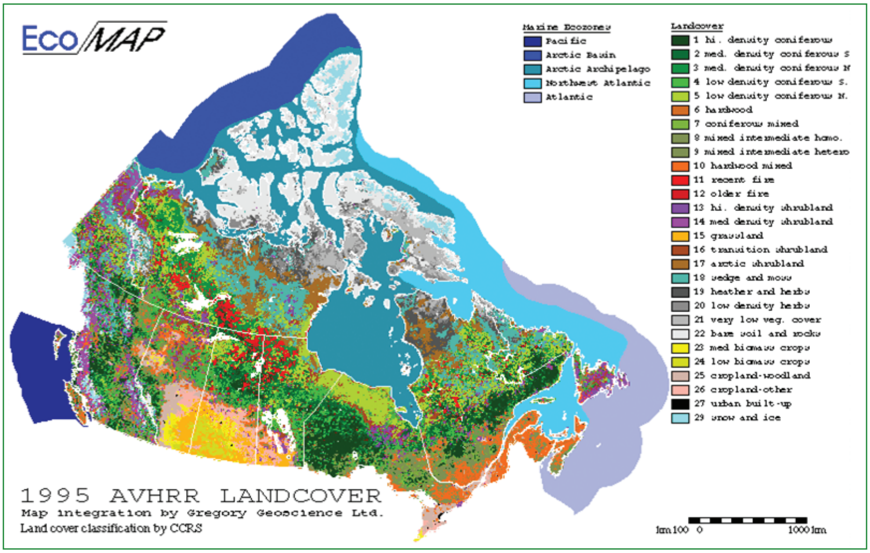


Figure 42. Biodiversity in Canada

3.1. Climate Change Biodiversity Monitoring

In 1992, the Smithsonian Institution initiated a global biodiversity observing program under the auspices of UNESCO (Dallmeier, 1992). Using standardized one-hectare plot sizes and measurement protocols for multi-taxa monitoring, the Smithsonian Institution Biodiversity Monitoring (SI/MAB) network now numbers more than 500 sites in approximately two dozen countries worldwide, with the majority of sites located in the Americas (Figure 43).

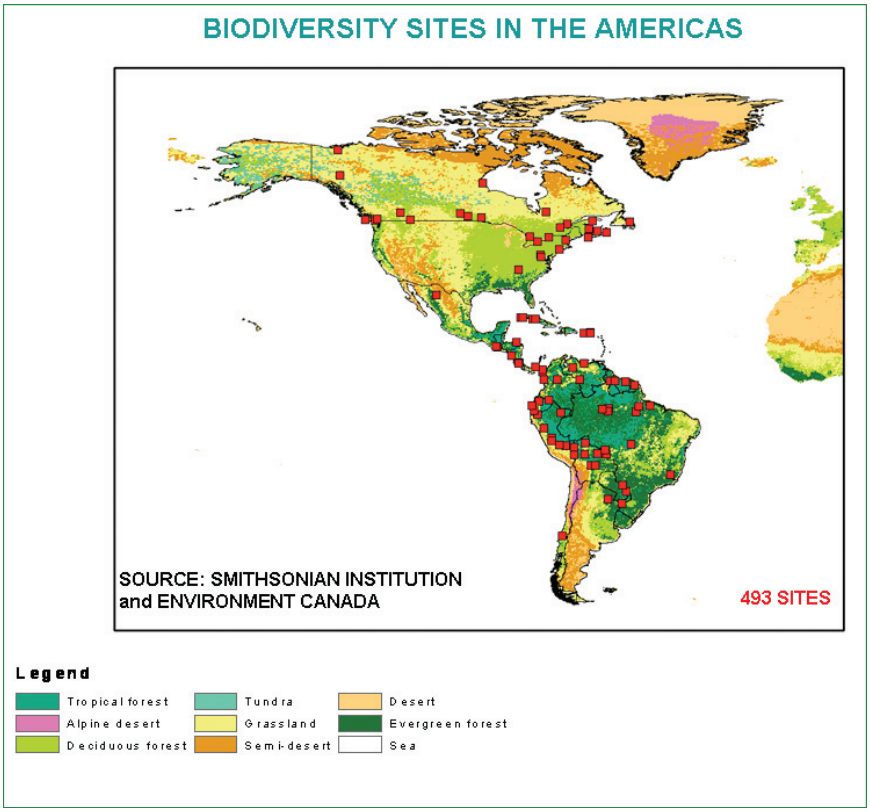


Figure 43. Distribution of SI/MAB sites in the Americas

One hundred and four of these sites are in Canada, located across climate, chemical and ecological gradients. Based largely in southern forest ecosystems, they are monitored by community groups.

In southern Ontario alone, there are at least 25 SI/MAB sites that allow for more detailed bioclimate analysis (MacIver, 1998; Environment Canada, 2003).

These sites deserve much of the credit for the extensive knowledge, information and climate and biodiversity monitoring databases that currently exist in Canada. Coast-to-coast examples of Canadian biodiversity observing sites are presented in section 3.3 as case studies.

The Global Forest Biodiversity Observing Network (SI/MAB sites) has the potential to provide an early warning prediction system of changes as a result of climate change. The network connects countries throughout the Americas with their respective SI/MAB sites and creates transects that run from the single pine species sites of the Cree community of Oujebougamou, Quebec, throughout North, Central and South America to return once again to the single pine species sites of Chile (Fenech et al., 2005).

A transect of biodiversity observing sites across physical, chemical and ecological gradients allows for unique investigations into the cumulative impacts of global change on forest biodiversity. (For example the use of the same measurement protocols allows for comparative studies in forest biodiversity and enables transect studies to interlink climate and biodiversity information together throughout the forests of Canada). The resultant information can increase our understanding of the impacts of climate change and help to further reduce the adaptation deficit of the Americas (Fenech et al., 2005).

3.1.1. Biodiversity Monitoring Applications

There are four general rubrics under which most biodiversity monitoring activities fall:

- monitoring based on species at risk;
- monitoring based on population trends;
- monitoring based on status and trends in habitat-based biodiversity; and
- monitoring based on threats to biodiversity (e.g., climate change).

Monitoring is critical for providing information about what impacts are actually occurring, validating existing models, improving ecological understanding, developing new models and assisting in the design of adaptation programs. Continuous monitoring will indicate whether or not populations are shifting and what changes, if any, have occurred to the natural system.

The focus of climate change/biodiversity monitoring is determining how those changes came about and to what extent they may be detrimental to the natural system and its resources. Monitoring can help with assessing what can be done to lessen harmful impacts to species and ecosystems and presenting better choices for society. Monitoring is also necessary to measure the state of the system and how it changes, as well as to track the effectiveness of adaptation methods.

Detailed biodiversity assessments provide the basic information for discovering the intricate links among species. With a well-established biodiversity baseline, indicator species can be selected for long-term monitoring (Alonso and Dallmeier, 2000). Table 3 shows the number of tree families and species in SI/MAB sites worldwide and Table 4 shows tree species identified in the international global monitoring sites as being at risk of extinction.

In addition, monitoring enables early detection of invasive species and disease, along with identification of bioclimatic changes that affect tree species composition and other key factors in biodiversity.

Table 3. Number of tree families and species in international SI/MAB sites

LOCATION	FAMILIES	SPECIES
World	146	2,334
North America	25	96
Central/South America and the Caribbean	103	1,304
Africa	98	765
Asia	59	223

Table 4. Red-listed tree species in international SI/MAB sites

SOUTH AMERICA (BOLIVIA, PARAGUAY)	AFRICA (CAMEROON, NIGERIA)
Aspodosperma polyneuron	*Afzelia africana* *Afzelia bipindensis* *Afzelia pachyloba*
Cedrala fissilis *Cedrala odorata*	*Cordia platythyrsa*
Balfourodenddron riedelianum	*Diospyros crassifora*
Minquarta guianensis	*Eribroma oblonga*
Virola surinamensis	*Gossweilerodendron balsamiferum* *Lophira alata* *Lovoa trichiloides* *Nauclea diderrichii* *Nesogordonia papaverifera*

Monitoring is critical after fires, droughts, floods and hurricanes, since pest invasions are often triggered by extreme events. When native species colonize rapidly in response to climate change events (including floods, cyclones, fire and warming) and achieve a high level of dominance (forming monocultures), it is crucial to know under what circumstances they are suppressing biodiversity and should be treated as invasives.

Monitoring is also highly useful in tracking management scenarios (e.g., managed versus unmanaged forest stands, prescribed burn versus control). In regions of high biodiversity, such as Ontario's Carolinian forests, monitoring is extremely important to capture the biodiversity baseline and its changes. Furthermore, monitoring of the forest tree species is only the first step: it must be emphasized that biodiversity is multi-taxa and not single species management.

3.1.2. Scale Dependency

Biodiversity is scale dependent. The relationship between spatial scales, plot sizes and biodiversity needs to be addressed from the outset of any project, since there are significant differences in the species/area relationships of different habitats. In many cases, the relationship is "hump-shaped," wherein forest diversity peaks at areas approximately one-hectare in size.

Figure 44 illustrates the scale dependency of forest biodiversity. Backus Woods and CARE sites in Ontario were compared to data from England collected by Crawley and Harral (2001), which showed that maximum diversity for minimum area occurs around the one-hectare size unit (Environment Canada, 2003). In the family-diversity-by-area continuum, the Carolinian mixedwood forests of Backus Woods – located in one of Canada's most biologically diverse areas – are very close to the peak of the curve, indicating that a sample size of one-hectare is required to adequately sample the maximum forest species within the minimum area. Preliminary analysis indicates that sampling an area smaller than one-hectare at Backus Woods yields significantly less families and species (Environment Canada, 2003). The CARE site, with a fewer number of

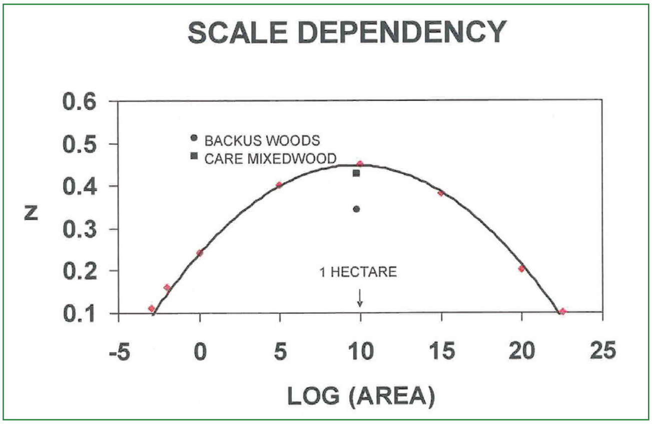


Figure 44: Scale dependence of the species/area relationship

The slope of the log species/log area curve, z, plotted against log (area)

families, peaks at the same scale, but its maximum value is less than the more diverse site at Backus Woods. This suggests that there might be a series of related curves illustrating the family-diversity-by-area relationship, with family diversity increasing with increasing area (up to a one-hectare size unit).

3.1.3. Current Status of the National Biodiversity Observing Network http://www.canadabiodiversity.ca

Information on the Network of Biodiversity Observing Sites (NBOS) in Canada can be found on **www.canadabiodiversity.ca**.

This Web site provides case study examples of coast-to-coast biodiversity in SI/MAB sites and analysis and information on atmospheric change and biological threats in Canada (Figure 45).

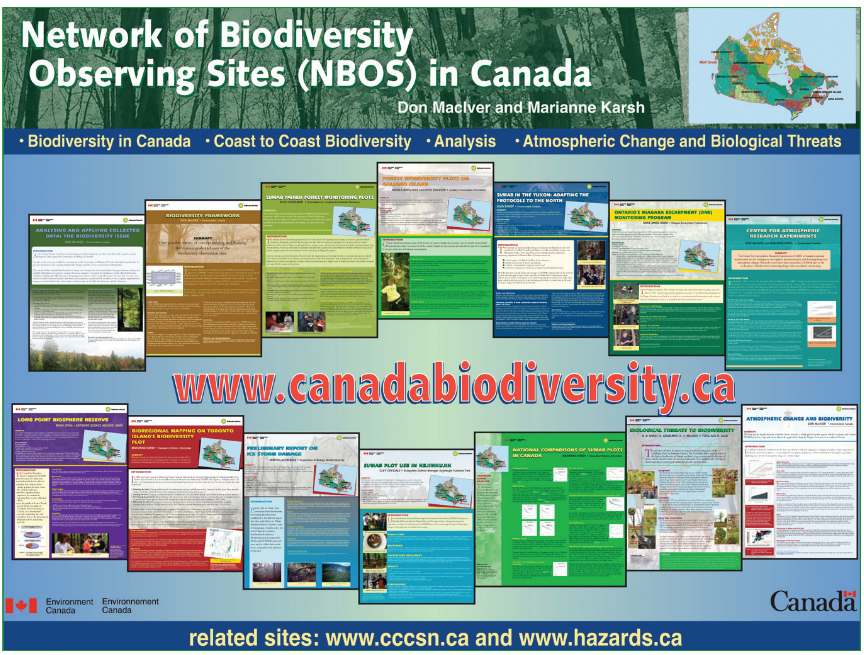


Figure 45: Network of Biodiversity Observing Sites (NBOS) in Canada

The Canadian SI/MAB baseline is represented by 104 forest biodiversity observing sites from coast-to-coast, with a predominance of sites in Ontario and Quebec. Table 5 shows the evolving and known SI/MAB sites across Canada, with Ontario and Quebec representing 58% of them, Atlantic Canada representing 19% and Western Canada and the North representing 23%.

Table 5. Distribution of NBOS sites in Canada by province and territory

PROVINCE/TERRITORY	NUMBER OF SITES
Alberta	2
British Columbia	14
Manitoba	5
New Brunswick	7
Newfoundland and Labrador	1
Northwest Territories	1
Nova Scotia	10
Nunavut	0
Ontario	48
Prince Edward Island	2
Quebec	12
Yukon Territory	2
Total	**104**

Of the 104 NBOS forest monitoring sites in Canada, 37 provided data to Environment Canada for data sharing and analysis. These include 20 sites in Ontario (two sets of measurements for Backus Woods), nine in Quebec, four in British Columbia, two in Nova Scotia, and one each in the Northwest Territories and Yukon Territory. The largest distribution of NBOS forest monitoring sites occurs in highly populated areas, namely the Mixedwood Plains, Atlantic Maritime, Boreal Shield and Pacific Maritime (Table 6).

Table 7 shows the distribution of NBOS sites by land ownership, with the greatest number established by research groups in government and universities, followed by national parks and biosphere reserves. To date, less than half of all national parks and biosphere reserves have established NBOS forest monitoring sites. As explained in section 4.1.2., this is a critical deficit, since most of Canada's parks and reserves are expected to experience shifts in dominant vegetation under climate change.

Table 6. Distribution of NBOS sites in Canada by ecozone

ECOZONE	NUMBER OF SITES
Arctic Cordillera	0
Atlantic Maritime	19
Boreal Cordillera	2
Boreal Plains	3
Boreal Shield	13
Hudson Plains	2
Mixedwood Plains	46
Montane Cordillera	6
Northern Arctic	0
Pacific Maritime	10
Prairies	2
Southern Arctic	0
Taiga Cordillera	0
Taiga Plains	1
Taiga Shield	0
Total	**104**

Table 7. Number of NBOS sites in Canada by land ownership type

LAND OWNERSHIP	NUMBER OF SITES
Aboriginal reserves	3
Biosphere reserves	19
Conservation authorities, nature and wildlife reserves	13
Education centres	4
Parks: National and historic sites	22
Parks: Provincial and territorial parks	8
Research stations: University and government	23
Other (private lands)	12
Total	**104**

BOX 9

Gaps: Climate change biodiversity monitoring

A comprehensive monitoring network for Canada is required. The current number of sites is inadequate as the sites are, for the most part, sites of opportunity – owned, operated and managed by community groups. The resulting gaps in the Canadian observation network are adversely impacting the ability of science to evaluate past, present and future biodiversity.

A nationally coordinated monitoring program, which would maintain or reinvigorate current long-term climate change/biodiversity monitoring sites and establish new ones, should be considered a priority. To meet the full range of monitoring requirements, permanent plot networks must be expanded across Canada to include sites subject to a broader range of climate extremes, human activities and impacts. Protected areas (IUCN), Global Biosphere Reserves (UNESCO) and Smithsonian global reference sites based on scientifically sound, standardized monitoring protocols are essential to provide an effective, community-based platform to monitor changes in ecosystem functioning and resilience.

Monitoring needs to be well coordinated nationally and have clearly defined goals and sampling designs that determine the variables to be monitored. Baseline and long-term monitoring information is crucial for defining manageable levels of change and for assessing climate change impacts.

Long-term climate change/biodiversity monitoring datasets are critical and will help contribute to global research on climate change. There is a clear need for bio-monitoring sites specifically set up to track climate change, few of which presently exist.

Despite a predominance of forest cover in Canada, the majority of climate stations are located in open areas instead of under forest cover, resulting in a dearth of information on forest climate.

Committed scientific research based on climate change/biodiversity monitoring sites is necessary.

There is a lack of true research sites and super sites with multi-taxa designs.

Data sharing among partners establishing biodiversity monitoring sites remains inadequate. Only when local climate biodiversity monitoring information is shared can trends across regions be identified.

3.2. Biodiversity Framework

The Canadian SI/MAB network continues to expand at an unprecedented rate. Using the SI/MAB protocols, numerous agencies have established one-hectare plots in forest environments or smaller biodiversity plots in grassland and tundra locations. The goals and objectives of each group are different, making it difficult to communicate respective methodologies and results in spite of the common focus: biodiversity. For this reason, a framework was established to delineate the diversity of goals and objectives faced by different groups using the same biodiversity site (MacIver, 1998). This biodiversity framework, shown in Figure 46, is one possible means of conceptualizing and framing the various goals and uses of biodiversity observation sites.

3.2.1. Conservation

The SI/MAB plots are intended 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). An example of this is Galiano Island (see Section 3.3.2.1).

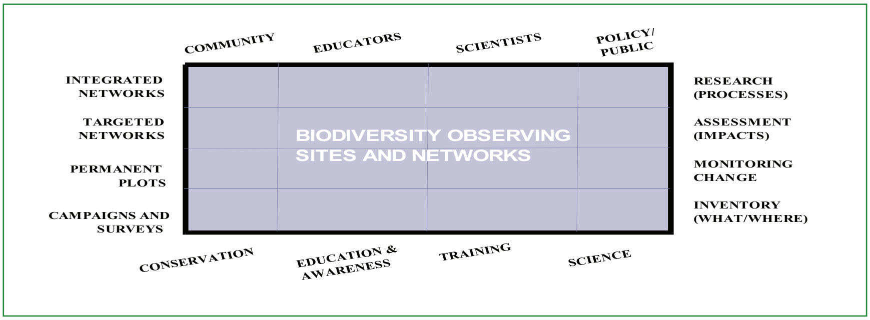


Figure 46: Biodiversity framework

3.2.2. Education and Awareness

Outdoor education centres, biosphere reserves, urban and rural schools, and universities often establish SI/MAB sites. Examples include sites along the Niagara Escarpment in Ontario, Humber Arboretum and Toronto Island.

3.2.3. Training

With demand for training courses increasing, quality control standards are essential for the subsequent electronic sharing of the biodiversity observations and scientific databases. This provides a unique opportunity to "train the trainers" using science-based protocols, thereby serving as a bridge between the educational and science sectors.

3.2.4. Science

The science category is the most limited in terms of number of sites but highly integrated scientifically. Locations such as Kejimkujik National Park in Nova Scotia and the Centre for Atmospheric Research Experiments (CARE) in Ontario are prime examples of collaborative biodiversity research that uses paired plots to evaluate unmanaged versus managed forest biodiversity. Also noteworthy in this respect is the work of the Ontario-based Association for Canadian Educational Resources (ACER) to understand human impacts on forest biodiversity.

3.2.5. Goals and Objectives

The vertical axes in the Biodiversity Framework grid highlight goals and objectives, with the bottom two levels focusing on structure and the upper two levels focusing on process. This matrix approach has proven effective in helping groups to establish goals, objectives and proper sampling designs, as well as to monitor deliverables. As the direction increases from left to right or bottom to top, an increasing level of expertise and resources is required, now and in the future.

BOX 10

Gaps: Biodiversity framework

Some cells in the Biodiversity Framework grid are not represented. Inadequately represented key areas include integrated and targeted networks and science, such as research on ecosystem processes, assessment of impacts and monitoring change.

In Ontario and Quebec and in Bisley, Puerto Rico, analysis has also underscored the value of using Smithsonian SI/MAB sites established prior to a climate extreme event (e.g., ice-storms and hurricanes) for direct comparisons of impacts.

More SI/MAB sites need to be established to fill key gaps in the Biodiversity Framework. Once these sites are established, financial and institutional support will be required to keep them active and sustainable.

3.3. Coast-to-Coast Biodiversity: The Canadian Baseline

http://www.canadabiodiversity.ca

The Canadian SI/MAB baseline operates within the context of a global biodiversity program using standardized monitoring protocols. This evolving Canadian baseline draws upon observations from more than 100 sites across the country.

3.3.1. Canadian Benchmark and Comparison to International Sites

Latitudinal gradients of diversity have been shown from high in the tropics to low in the Arctic. Peru averages 152 different plant species per hectare, with a diameter of 10 cm or more. In northern Europe, the average is 18 species per hectare and in the eastern United States, it is 29. In Canadian sites, the average number of tree species is 11 per hectare.

Black spruce at Charlevoix is an important Canadian monoculture benchmark; however, this is only one tree family per hectare compared to nearly 50 in South America (Figure 47). Backus Woods in the Carolinian region and Bisley in the Caribbean have similar numbers of species (<15), while Dikola, Cameroon, has around 30 families per hectare.

In a northern ecosystem, the conservation of a single species may be more critical to the way that ecosystems function than it would in a highly diverse tropical ecosystem, with its abundance of species and genetic variations. Canada can ill afford to lose even one species in an environment where species have specifically adapted to harsher conditions.

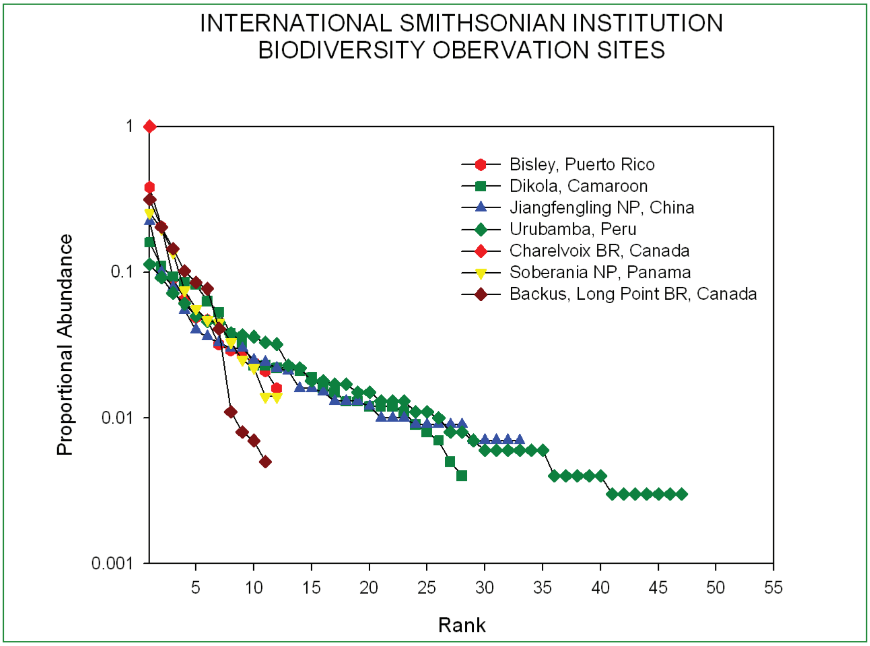


Figure 47: Diversity in international SI/MAB sites

3.3.2. Canadian Case Studies
http://www.canadabiodiversity.ca

The first case study features old-growth Douglas fir (*Pseudotsuga menziesii*) and Garry oak (*Quercus garryana*) and Arbutus ecosystems in British Columbia. The number of pristine temperate West Coast rainforests keeps shrinking, which is why substantial efforts have been made to monitor changes in biodiversity on Galiano Island in British Columbia (section 3.3.2.1.).

Northern monitoring efforts are illustrated for very dense and slow growing white spruce (*Picea glauca*) ecosystems in the Yukon and Northwest Territories. Also included in this category are the black spruce (*Picea mariana*) ecosystems, Canada's baseline, in northern Quebec (section 3.3.2.2.).

The wide diversity of southern Ontario is represented by sugar maple (*Acer saccharum*) forests along the Niagara Escarpment (section 3.3.2.3.), managed and unmanaged red pine (*Pinus resinosa*) forests at the Centre for Atmospheric Research Experiments (CARE) (section 3.3.2.4.), unique and highly diverse Carolinian and Oak-Savannah ecosystems at Long Point Biosphere Reserve (section 3.3.2.5.) and a climate change experimental site in Toronto's Humber Arboretum (section 3.3.2.6.).

The Ontario case studies show examples of how biodiversity is reduced by human impact at the Toronto Zoo site and by forest management practices (controlled burns) at Long Point. They also provide examples of the value of using tree coring and Tree Ring Analysis to complement biodiversity monitoring, and of how climate research towers co-located in biodiversity monitoring sites can yield information on soil freezing and soil buffering capacity. The Long Point case study also illustrates how community volunteers can be invaluable as part of an early warning system to identify invasive species.

Ice-storm-impacted sugar maple and mixedwood maple ecosystems are featured for eastern Ontario and Quebec (section 3.3.2.7.). These case studies show the value of locating sites in areas prone to experiencing climate extremes and evaluating biodiversity before and after impacts.

The final case study looks at Canada's East Coast, which is represented by mixed softwood and hardwood stands in Nova Scotia (section 3.3.2.8.). This particular case study is included to show how useful one-hectare biodiversity monitoring sites can be for researching multi-taxa and identifying previously unknown species. Detailed information and photos for each of the case studies can be viewed at **www.canadabiodiversity.ca**.

3.3.2.1. Old-Growth, Rare, Endangered or Endemic Populations in B.C.

Galiano Island encompasses more than 6,000 hectares of the coastal Douglas fir ecosystem, one of Canada's most limited biogeoclimatic zones. Less than 2% of the coastal Douglas fir zone is protected and almost all of it has been altered by resource extraction and human encroachment.

In this coastal temperate rainforest of British Columbia, previously unknown invertebrate species, unique to the canopies of coastal old-growth forests, have recently been identified. At the same time, overgrazing by livestock and the eastern cottontail rabbit, an introduced species, has facilitated the rise of many non-native plant species. Urbanization, invasion by exotics (such as the European gypsy moth and Scotch broom) and agricultural activities can all contribute to the degradation of habitats like Galiano that are home to many endemic species.

Designated an "Ecosystem at Risk," this ecologically significant area contains many diverse and healthy ecosystems besides the remnant old-growth coastal Douglas fir forest: a freshwater lake and creek, naturally regenerated forest and a healthy, younger Douglas fir plantation. Through outright purchases, partnerships, co-management and conservation covenants, the Galiano Conservancy Association has secured protected status for 14% of Galiano Island. Since most of the island remains privately owned, the association also undertakes many public education projects to raise conservation awareness.

In 1996, the Galiano Conservancy brokered a conservation agreement between key government and non-governmental organizations to protect and designate the Pebble Beach Reserve. Once established, the 322-acre reserve had to be monitored to see how well conservation efforts were actually protecting biodiversity. The SI/MAB protocol for forest inventories provided the ideal framework to make such an evaluation.

After undergoing formal training on the international SI/MAB forest inventory protocols, the Galiano Conservancy established the Pebble Beach Reserve's first SI/MAB site in 1999. Two years later, a second one-hectare plot was established. Since then, five additional 20-by-20-metre quadrats have been added to include a stream and riparian area. A salamander monitoring program has also been launched, along with inventories of vegetation, soils and coarse woody debris in selected quadrats.

With its rare remnant of old-growth forest, naturally regenerated second-growth forest and healthy young Douglas fir plantation, the Pebble Beach Reserve site offers unparalleled opportunities for biodiversity research and comparison studies of different stands on adjacent permanent plots. Meanwhile, the original one-hectare plot continues to provide a reference ecosystem for restoration treatment areas. Analysis of data collected over time will record baseline biodiversity characteristics never available before, including evidence of the ecosystem's dynamics.

A 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 of the consequences of disrupting ecological relationships and the rehabilitation of natural system functioning may also help to slow biodiversity loss.

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 Canada. The proportional abundance curves in Figure 48, which represent the Garry oak and Douglas fir sites on the West Coast, are typical for old-growth sites with few species: a high proportion of one or two tree families and then a rapid drop in proportional abundance. The other two to three tree families are in relatively low proportions in the understory.

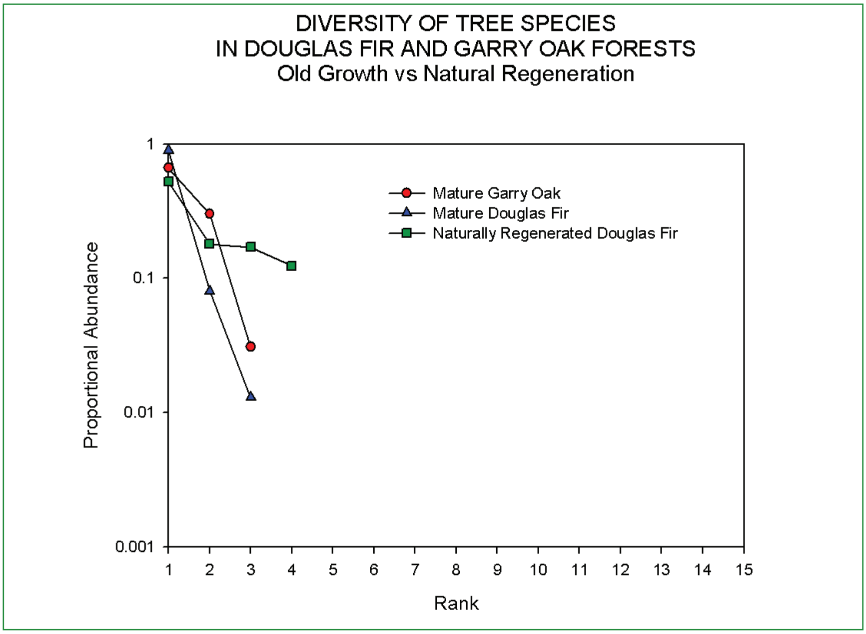


Figure 48. Diversity of tree species in Douglas fir and Garry oak forests, B.C.

In contrast, the proportional abundance curve for the naturally regenerated Douglas fir stand shows higher abundance and a greater number of species in the understory. While old stands are not necessarily particularly rich in species, some species are clearly dependent on them. The old-growth Douglas fir site in British Columbia has three tree families, while the new Douglas fir regeneration site has four. The Garry oak site, also with three tree families, has a similar pattern of proportional abundance as the mature Douglas fir site.

3.3.2.2. White and Black Spruce Forests, Yukon, N.W.T., and Northern Quebec

Two SI/MAB sites were established in the Wolf Creek Research Basin in the Boreal Cordillera ecozone with four key objectives: 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.

The Wolf Creek sites are located 15 km south of Whitehorse, Yukon, in relatively pristine forest. One of the sites contains trees dating back to the 1700s. Several fires have damaged the trees, the most recent occurring in 1950. There is no evidence of heavy insect infestation or logging. Tree species include white spruce, lodgepole pine (*Pinus contorta*), balsam poplar (*Populus balsamifera*) and several willow (*Salix*) species.

The sites are part of a larger, long-term multidisciplinary research project on climate change, vegetation, forestry, fisheries and wildlife in the Wolf Creek drainage basin, where three climate stations are also situated. To date, past and present monitoring includes breeding bird surveys, a soil fungi survey and tree coring for fire/insect history. Future monitoring may include forest ground vegetation, fungi, insects (i.e., density and diversity in relation to canopy structure), spiders, and leaf and log decay.

Patchiness is the main variability in forest communities around Whitehorse and is related to elevation, aspect and soil type. Based on aerial photographs, a digital elevation model and limited ground truthing, a vegetation classification system was developed for the Wolf Creek Watershed. One SI/MAB site was established in each of two of the five forest vegetation classes.

High tree density (2,600-3,700 tree stems per hectare) made mapping of tree positions difficult, as trees were often only centimetres apart. Although the SI/MAB standard for measuring a tree in a plot is 10 cm diameter at breast height (dbh), many sites in Canada include trees down to 4 cm dbh. It was decided to reduce this further to a minimum size of 2.5 cm, consistent with the minimum dbh used for forest inventory sites in the north, where slow growth is typical.

The biodiversity monitoring site at Gwich'in, Northwest Territories, consists predominantly (89-99%) of white spruce. Both the white spruce forests at Gwich'in and Wolf Creek are typical of the region, which features a predominance of one or two natural single species forests that have adapted to the local ecology (Figure 49). The number of species decreases further north in the Boreal Cordillera ecozone, with a high predominance of forests populated by a single tree species (monocultures) in the North Boreal/Barren areas.

Softwood-dominated stands, namely at Forillon and Mingan Archipelago, have three to four tree families. Permanent shifts from softwood to hardwood cover are occurring in these areas, where harvesting has replaced fire as the dominant disturbance. The combination of clear-cutting and fire suppression favours trembling aspen (*Populus tremuloides*) and white birch (*Betula papyrifera*) to the detriment of conifer species such as black and white spruce and jack pine (*Pinus banksiana*).

There are three sites in black spruce forests: two at Charlevoix and one at La Mauricie, Quebec. These stands have between one and two dominant tree families, with an extremely high composition of black spruce (>95%) and an average of 2,200 stems/ha. Because this is such an extensive and important ecosystem and because there is only one species on the site, black spruce represents the benchmark species for forest diversity curves in Canada (Figure 49).

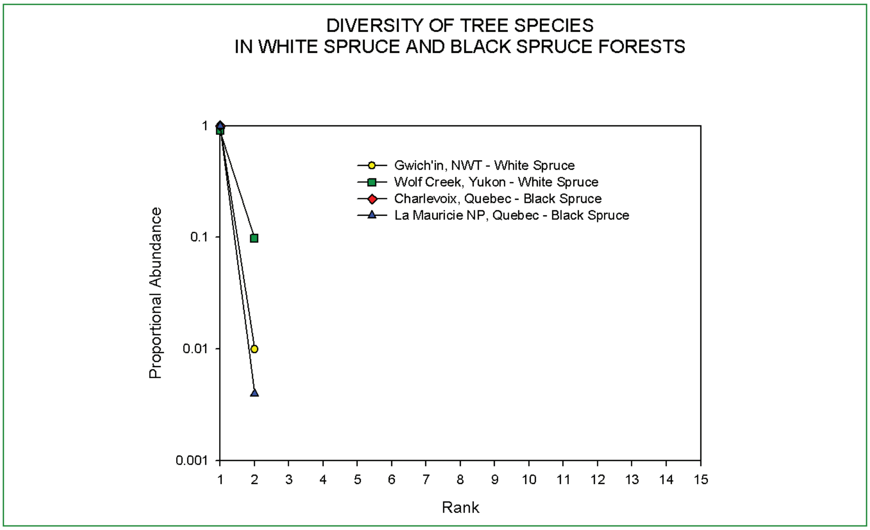


Figure 49. Diversity of tree species in white spruce and black spruce stands

3.3.2.3. Sugar Maple Forests, Niagara Escarpment, Ontario

The Niagara Escarpment Plan, Canada's first large-scale environmental land use plan, came into effect in 1985. Created by government legislation, its goal 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." A long-term monitoring strategy was designed to assess if the plan is achieving its mandate in the areas of terrestrial ecology, water, recreation, open landscape character, public access and land use.

The body charged with enforcing this strategy, Ontario's Niagara Escarpment (ONE) Monitoring Program, decided to adopt the SI/MAB protocols to track long-term biodiversity changes along the escarpment. Sites have been established at: 1) Hilton Falls, a transitional zone between the Carolinian Region and the Southern Deciduous-Coniferous Forest Region left relatively undisturbed during human settlement; recently, however, it has been impacted by conifer plantations, road construction, recreational use and selective logging; 2) Hockley Valley, a 16-km-long contiguous forest block that was largely cleared of mature trees and later reforested; 3) Cabot Head, used as a logging and mill site in the late 1800s and early 1900s; and 4) Skinner's Bluff, which was selectively logged 30 years ago and is currently experiencing some impact from the nearby Bruce Trail.

Additional sugar maple sites have been established along the Niagara Escarpment by the Association for Canadian Educational Resources (ACER) in partnership with Natural Science Schools and Outdoor Education Centres. These include sites at Wiarton, Mono Cliffs, Albion Hills, Boyne River and Royal Botanical Gardens. There are sugar maple sites also at the Metro Toronto Zoo and Bruce National Park.

The sites were set up for long-term monitoring and it is hoped that comparisons of monitoring variables (e.g., native floristic quality, species abundance, biomass, canopy height) can be made between "control" and "pressure" SI/MAB sites. Relatively undisturbed or "control" sites are located in areas along the escarpment that have the highest level of protection. Biodiversity in control sites can be compared with biodiversity in "pressure" sites that have been subjected to greater human disturbance to determine the effects of development on the natural environment. Monitoring of these sites will help increase understanding of forest dynamics and ecosystem processes to better assess the impact of disturbance and predict change.

SI/MAB sites also provide the opportunity for additional research activities, such as monitoring tree health and ground vegetation, while students who collect the data gain important theoretical and practical knowledge of environmental monitoring. The data collected in the sites can build on the information gathered through other programs, such as the Forest Bird Monitoring Program of the Canadian Wildlife Service.

The four Niagara Escarpment sites number among the more than 31% of sites in the total Canadian SI/MAB database that are sugar maple forests. Typically associated with the latter stages of succession, sugar maple is one of Eastern Canada's most important hardwood species, valued for its wood and syrup.

The proportional abundance curves for the sugar maple forests in the Niagara Escarpment represent five sites on a north/south transect (Figure 50). Mono Cliffs is shown as a single point as this site has not yet started to diversify (Figure 51). The Metro Toronto Zoo site, which has the least number of tree families and the highest level of compaction, illustrates how diversity appears to decrease as human impact increases if there are no invasive species occupying the site as a result of land-use changes.

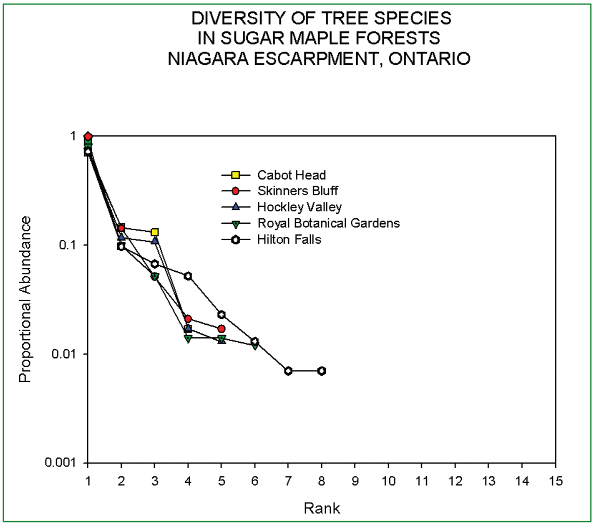


Figure 50. Diversity of tree species in sugar maple stands

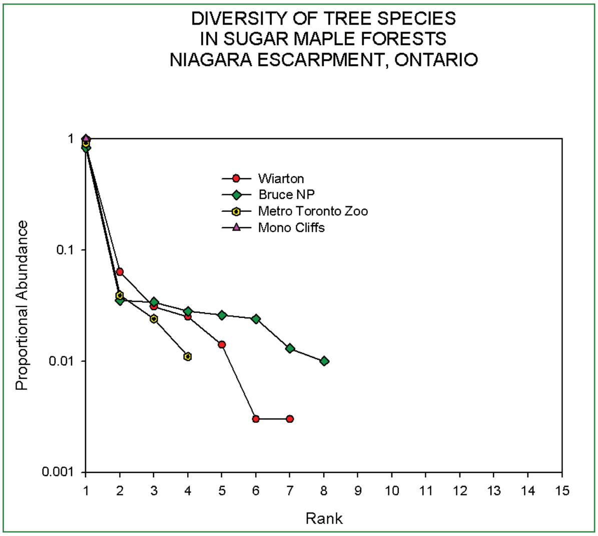


Figure 51. Diversity of tree species in sugar maple stands and human impact

3.3.2.4. Red Pine Plantations at CARE, Ontario

Established in 1988, the Centre for Atmospheric Research Experiments (CARE) is Canada's national experimental site for testing new atmospheric instrumentation, as well as for detecting long-term atmospheric change.

Between 1988 and 1994, a SI/MAB site was located in the planted red pine plantation; a second paired plot was established in the unmanaged mixed hardwood forest. Instrumented climate research towers for temperature, humidity, wind and radiation monitor the horizontal and vertical profiles of heat, moisture and wind in these sites. The towers are situated in standard open site locations, openings in the forest, forest edges and closed forest environments. This co-location of biodiversity monitoring, along with atmospheric monitoring, marks an important step forward.

One finding to emerge from research at the CARE site is that forests can potentially have a profound buffering impact on changes in climate. Figure 52 illustrates the buffering capacity of forest soils: for every 2°C change in temperature in the open, there is a 1°C change in the forest climate. This buffering capacity protects animals from overly rapid temperature increases and mitigates the effects of climate change on resident populations by providing an oasis with a cooler climate. As an insulation layer for many species during their life cycle, snow cover can also provide additional buffering capacity. It is crucial to maintain and institutionally support the climate stations in order to continue to study soil buffering capacity and soil freezing.

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. Invasive alien species, which are more readily suited to this new climate, will become increasingly prevalent. A forest climate monitoring program in highly altered landscapes needs to be co-located in the SI/MAB sites to understand the biometeorological exchanges and processes that influence biodiversity.

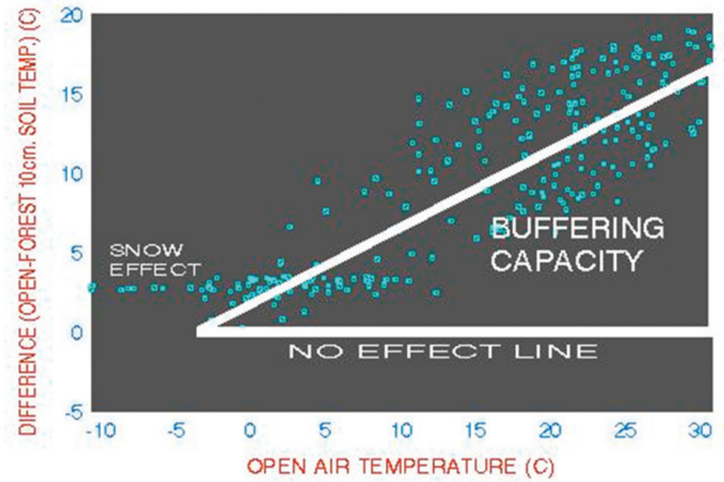


Figure 52. Thermal buffering capacity of forests to a changing climate

Part of the research at the CARE site used the technique of coring trees, as recommended by the international Smithsonian Institution vegetation monitoring protocols, to accurately gauge age and rates of growth. Examination of the increment core of a red pine in the first biodiversity site at CARE revealed that the year of planting was 1937.

Between then and 1941, there was a rapid increase in average ring width at diameter at breast height (dbh) from 1 cm to approximately 8.5 cm. Ring widths decreased steadily 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 (Figure 53). This indicates the tree was heavily impacted early in its life and shows the detrimental effects of overly close spacing and lack of thinning in 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.

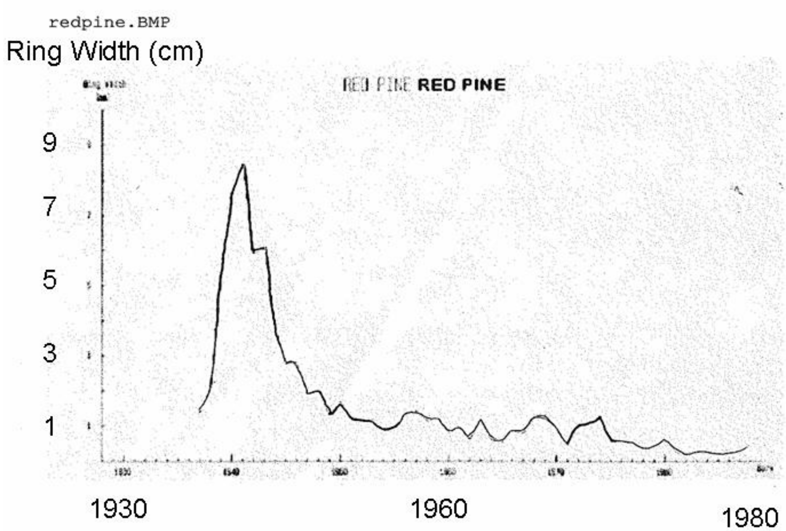


Figure 53. Average ring width of a red pine tree at CARE

The managed red pine plantation at the CARE site currently has seven tree families (Figure 54). It took about 60 years between the initial planting in 1937 and 1988 for natural reintroduction of seven new species into the stand. Thus, it appears that a managed plantation, if left unmanaged (i.e., no thinning or pruning later on in the stand's history; no removal of dead or dying trees), will tend toward increasing biodiversity.

It may take at least another 100 years for trees in the understory to mature so that the canopy will become a true mixedwood canopy, suggesting that the natural rate of biodiversification will not keep pace with the impacts and stresses associated with the anticipated rates of climate change. This underscores a potential maladaptation process in forests and a subsequent need for human intervention, such as planting to enhance diversity and increase forest adaptivity.

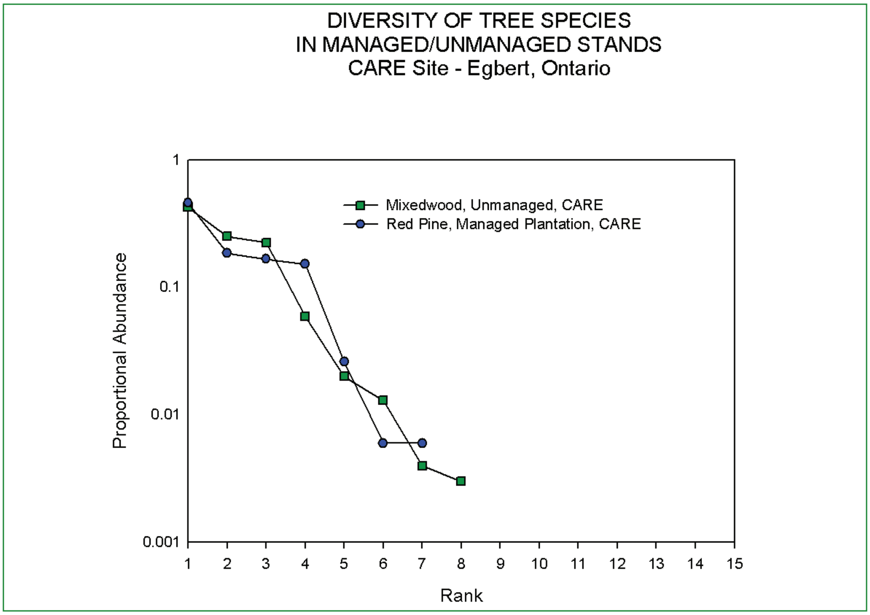


Figure 54. Diversity of tree species in red pine and mixedwood stands at CARE

Tree Ring Analysis was conducted at the CARE biodiversity sites to augment research findings. Using the Tree Ring Increment Measuring (TRIM) system, radial measurements of average ring width on cross-sections sampled along a tree stem (every 50 cm or less) produced a curve representing the growth layer profile (GLP).

Figure 55a shows the GLP (width) for a mature red maple (*Acer rubrum*) from the unmanaged stand, whose age can be traced back to 1943. It reveals a slow establishment phase for the first seven years until 1949. After that point, the tree added incrementally larger ring widths along the length of the tree stem. It experienced some high growth years in 1956, 1957 and 1960, but showed net annual decreases in ring width from 1958-59 and 1961-66. The most striking decreases occurred in 1962 and 1966. The tree started to respond and recover from 1967-69 and then, less noticeably, from 1980-82. From 1970-79 and 1983-88, it showed overall annual decreases in growth. In 1988, there was hardly any ring width along the stem.

An examination of the GLP (area) (Figure 55b) reveals that the upper portion of the stem is never fully developed and that 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, indicative of 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.

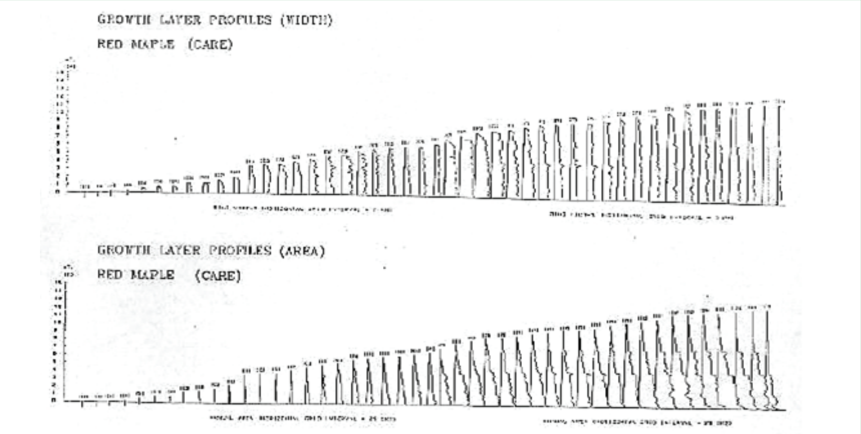


Figure 55. GLP (width) and GLP (area) of a red maple tree at CARE

3.3.2.5. Carolinian Forest and Oak-Savannah Ecosystems, Ontario

The Carolinian forest contains some of the highest biodiversity in Canada but is losing green areas and attendant diversity of species in patterns identifiable all the way from the local to the global. Changes in climate and disease patterns put additional pressure on these areas. Today, Carolinian forests survive only in scattered woodlands in southern Ontario, including Long Point, Ontario, an important biosphere reserve.

The Long Point Biosphere Reserve adopted the SI/MAB protocol in 1995 as part of a long-term forest biodiversity monitoring initiative.

Four one-hectare monitoring sites were established: two in Carolinian forests (Backus Woods and Wilson Tract); and two in Oak-Savannah forests (Turkey Point Sites 1 and 2).

The objectives were to: 1) monitor and compare forest change in protected areas versus the working landscape; 2) provide a quality learning experience for students by engaging them in data collection efforts; 3) raise the profile of Backus Woods, one of the best examples of Carolinian forest remaining in Canada, as an international network monitoring site; and 4) contribute data to the international biosphere reserve monitoring network.

Backus Woods is a prime example of an old-growth Carolinian forest composed primarily of oak and maple species. Wilson Tract, by contrast, is a managed Carolinian forest that has been subjected to periodic timber extraction. The two sites in Turkey Point Provincial Park show examples of 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) have also been collected, mostly by volunteers using SI/MAB protocols.

A 2000 re-inventory of Backus Woods revealed an alarming trend among eastern flowering dogwood (*Cornus florida*), a species that reaches the limit of its northern distribution in southern Ontario. Over a five-year period, the number of dead standing dogwood increased from 15 to 46%. After eight years, the majority of the eastern flowering dogwood died (Figure 56). Analysis of samples by the Canadian Forest Service attributed this increased mortality rate to Dogwood anthracnose (*Discula destructiva*), a fungus believed to be recently introduced in Canada, possibly on nursery stock from Asia (Britton, 1993). Left unchecked, Dogwood anthracnose could destroy most of the eastern flowering dogwood in Ontario within the next five to 10 years (Frontline Express, Canadian Forest Service, 2001).

Analysis of proportional abundance in these stands showed greater diversity in the old-growth unmanaged Carolinian site, which – with 11 tree families, versus the managed Carolinian site with nine – represents Canada's highest forest diversity baseline. The Oak-Savannah sites are much less diverse, with three to five tree families per hectare (Figure 57).

Forest management practices and impacts further reduce biodiversity. There are five families in the unmanaged Oak-Savannah site compared to three families in the managed (prescribed-burn) Oak-Savannah site (Figure 57).

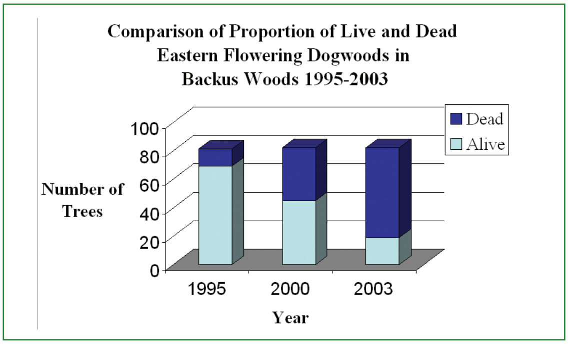
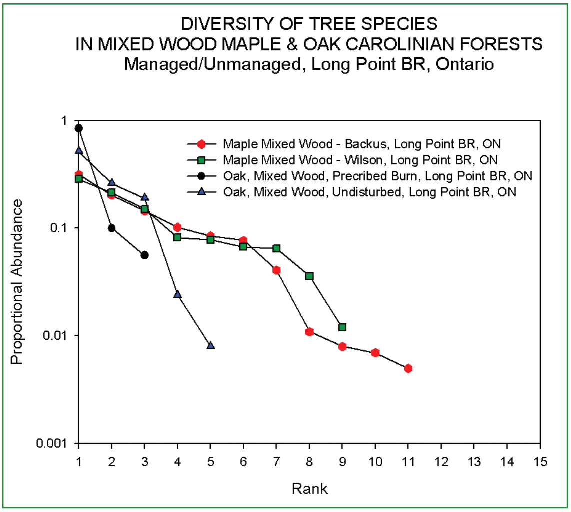


Figure 56. Survival of eastern flowering dogwood at Long Point Biosphere Reserve

Figure 57. Diversity of tree species in Oak-Savannah and Carolinian forests



3.3.2.6. Humber Arboretum Climate Change Experimental Site, Ontario

The Association for Canadian Educational Resources (ACER), Humber Arboretum, Arborvitae and the Atmospheric Science and Technology Directorate of Environment Canada's Adaptation and Impacts Research Division developed a climate change experimental site at Toronto's Humber Arboretum to monitor the impacts of biological threats on urban forest biodiversity. A key goal of the project was to investigate how forest planting design and selection of species might be used to help optimize biodiversity and ensure increased climatic resilience of species under current and changed climate conditions, particularly in urban forests.

Approximately 2,157 trees and shrubs were planted in 2002 and 2003 in a one-hectare biodiversity site with 25 quadrats, each 20 metres by 20 metres in size. Seventy-six different species of trees and shrubs were planted – an unprecedented number of species for a community planting project. As well as planting for biodiversity and climatic warming, the project also incorporated strategies for disease resistance: no more than 5-10% of any one species, no more than 20% of species in the same genus, and no more than 30% in the same family.

The Toronto urban location proved particularly beneficial for study. Toronto is home to 2.5 million people; approximately one-third of Canada's population lives within a 160-km radius of the city. The urban core has a well-documented warming bias relative to surrounding rural sites of nearly 4°C in minimum temperatures. This "Toronto warming effect" includes thermal influences from the city's location on the shoreline of the Great Lakes, as well as urban heat island effects.

The degree of warming in the Toronto core relative to nearby rural areas is consistent and within the range of anticipated future warming, presenting a "living laboratory." The current observed differences in minimum temperatures serve as an important indicator to help assess the responses of vegetation to warming through comparison with rural sites outside of the city.

Climate warming in urban habitats is associated with increased frequency and outbreaks of pests, as well as expansion of the range of deer and rabbits, whose population tends to increase with warmer springs. Despite protecting the trees with tree collars, browsing in the Humber Arboretum site was considerable, resulting in 20-80% mortality among newly planted seedlings in all quadrats after five years. Every tree still living, with the exception of white spruce, showed signs of heavy or severe browsing that could affect future growth, survival, reproductive success and competitive ability (Figure 58). The take-home message for managers is to plant trees that are larger sized and more resilient to deer browsing in the urban landscape.

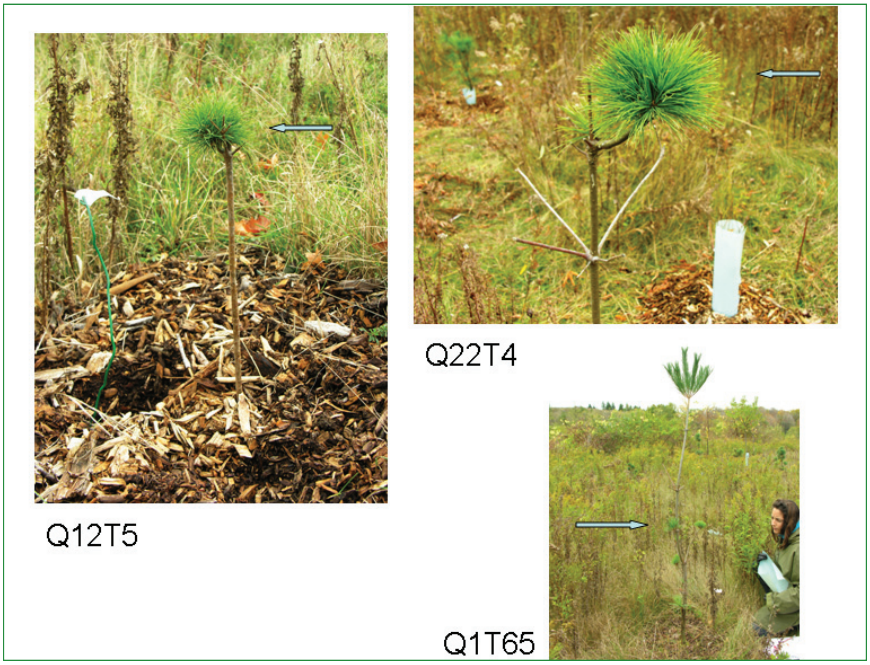


Figure 58. Impact of browsing on white pine at the Climate Change Experimental Site

3.3.2.7. Ice-Storm Damaged Stands, Eastern Ontario and Quebec

In January 1998, an area from Kingston, Ontario, to the Atlantic Maritimes was struck by the worst glaze ice storm of the century. The impact of the storm was concentrated in the valley of the St. Lawrence River, with the zone around St-Jean-sur-Richelieu, southeast of Montreal, being the most heavily hit.

Prior to the ice storm, four permanent forest biodiversity monitoring sites had been established in the affected region: two sites at the Mont St. Hilaire Biosphere Reserve, Quebec; a site at Gananoque, Ontario; and a site at Ste-Hippolyte, Quebec. SI/MAB protocols were used to collect data on the forest composition and structure of the sites. The Mont St. Hilaire Biosphere Reserve at Lake Hill and Botany Bay were originally intended to study long-term forest dynamics in an area of old-growth forest; the plots now serve as study sites for monitoring the recovery and mortality of trees affected by the ice storm.

After the storm, a quantitative assessment of the damage to all four one-hectare plots was conducted. Since the Mont St. Hilaire Biosphere lay within the zone of greatest damage, a more global estimate of damage within the reserve's forests was undertaken 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 Quebec Ministry of Natural Resources in their province-wide evaluation of the ice storm's impact.

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

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 indicates 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. Tracking individual stems in these sites over the next five to 10 years will help to establish reliable data on the fate of stems and species with different amounts of branch loss.

In the summer after the storm, it was clear that almost all sectors around the Mont St. Hilaire Biosphere Reserve 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 (*Quercus rubra*) and beech (*Fagus*) contributed nearly as much debris. These three species accounted for over 90% of the down biomass on the mountain as a whole.

Evaluation of these sites after the storm has allowed for the assessment of damages to the natural environment and has also yielded baseline data that can now be used to pursue research on ecological recovery. In addition, studying the long-term effects on the trees' mortality and recovery rates provides useful information for predicting mortality and recovery rates and possible outcomes of future drastic weather events precipitated by climate change.

After the ice storm, local and provincial authorities cut down many trees only to find that the trees had a high resiliency to the ice-storm damage and were able to recover after a period of time. It appeared that trees with <50% crown damage from the ice storm could recover after two years. Knowledge of the critical ice-storm indices for biodiversity could have reduced the huge losses of trees cut down as a reactive response to the ice storm – many more trees than were originally damaged by the storm.

The sugar maple sites in Quebec (Lake Hill, Laurentides) have four tree families, while the maple mixedwood sites at Botany Bay and Grosse Île, Quebec, have five to seven (Figure 59). The maple mixedwood sites at Gananoque, Tiffin and Long Point, Ontario, show very similar patterns of proportional abundance, with the two Carolinian sites at Long Point having nine to 11 tree families and the maple mixedwood sites at Tiffin and Gananoque having between six and eight (Figure 60).

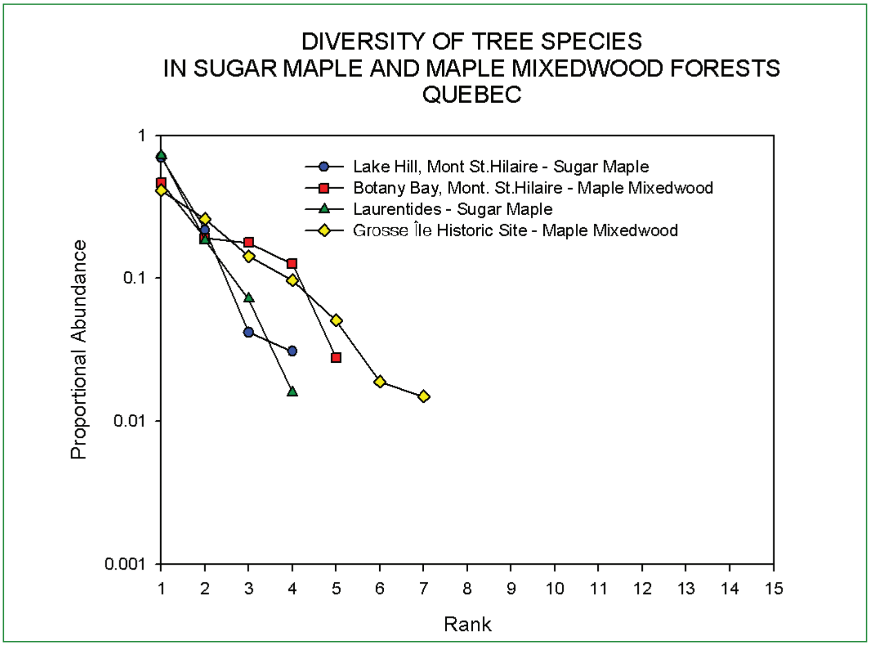


Figure 59. Diversity of tree species in sugar maple and mixedwood stands in Quebec

3.3.2.8. Mixed Softwood and Hardwood Stands, Nova Scotia

With its glaciated, rolling drumlin interspersed with lakes and streams, Kejimkujik National Park typifies the topography of southwestern Nova Scotia's Atlantic Coastal Uplands region. For 4,500 years, the area has been used by the Mi'kmaq peoples, who travelled the inland waterways from the Fundy Coast to the Atlantic.

Use of SI/MAB sites in Kejimkujik National Park and National Historic Site began as both a training exercise and an experiment to evaluate the utility of the SI/MAB protocol for monitoring the impact of long-range transport of air pollutants on Nova Scotia Acadian forest ecology.

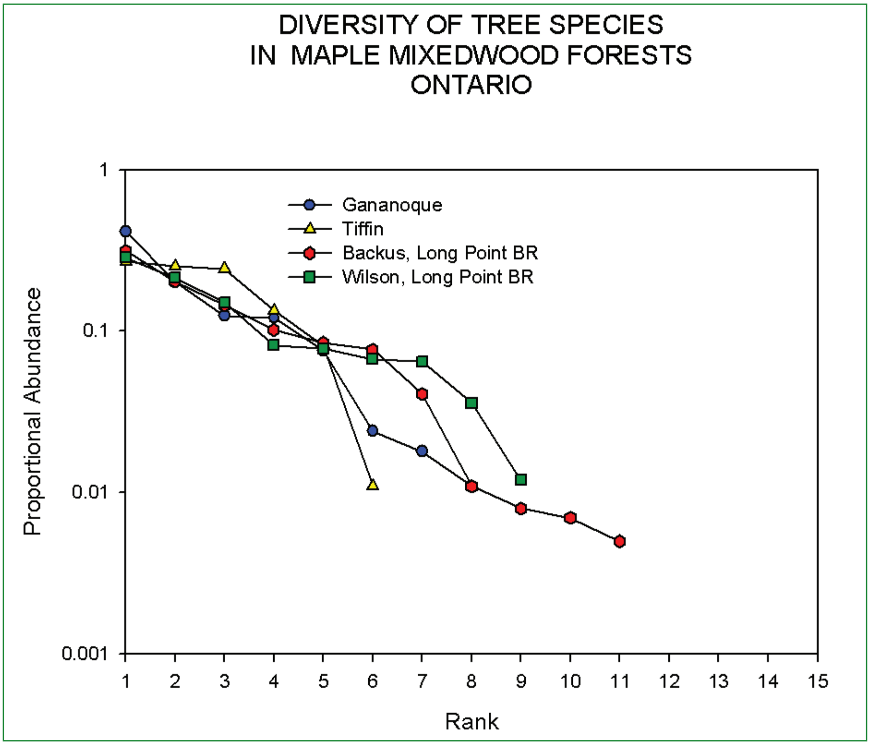


Figure 60. Diversity of tree species in mixedwood and Carolinian stands in Ontario

The first two SI/MAB sites were established in 1994. Site 1 was installed in a mixed hardwood stand, while Site 2 was placed in a mixed softwood stand. Both sites were representative of typical park forests.

With participants in the plot installation exercise coming from government agencies, academic institutions and industry, the creation of the sites generated significant interest in multidisciplinary, site-based monitoring. Research agencies and educational institutions recognized the opportunity to carry out site assessments for a variety of abiotic and biological components at the sites: forest microclimate, soil chemistry, basidiomycete and decay fungi, lichens, micro-invertebrates, forest canopy Lepidoptera and forest bird sampling.

Representatives of the forest industry expressed interest in having SI/MAB sites to evaluate harvest and silviculture techniques. This led to the installation of SI/MAB sites and replicate quadrats outside park boundaries on commercial forestlands. These were paired with control sites inside the national park, monitoring forest birds, ground vegetation and tree regeneration.

Figure 61 compares the diversity of the two sites. Mixed softwood site with eastern hemlock (*Tsuga canadensis*) and balsam fir (*Abies balsamea*) has four tree families, while the mixed red maple site has eight tree families. Soil chemistry analysis determined that calcium values at the sites were among the lowest in North America, further substantiating concern about acid deposition levels and the potential impact to sustainable forestry. Studies of forest soil invertebrates examined the collembola, mites, soil mollusca and myriapoda.

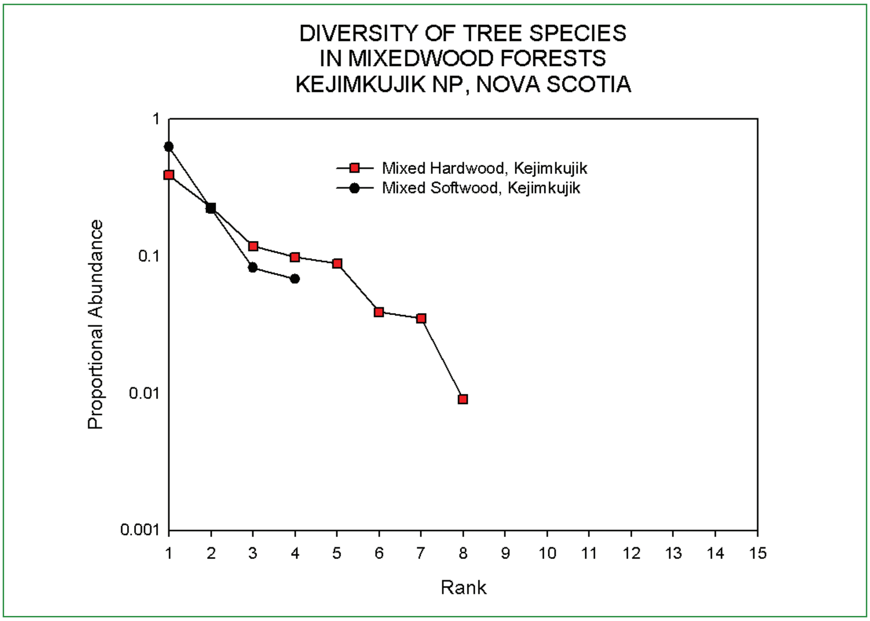


Figure 61. Diversity of tree species in mixedwood stands in Nova Scotia

The majority of myriapoda found at the study sites were exotic species. The forest canopy lepidoptera monitoring at Site 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 also made there. In addition, a variety of acid-sensitive lichens and basidiomycete fungi have been identified at the site, as well as a number of fungus species new to Nova Scotia.

BOX 11

Gaps: Coast-to-coast biodiversity: The Canadian baseline

There is a need to identify the critical ice-storm indices for biodiversity, as well as other climate extreme indices, to supply the knowledge needed for sound management and policy decisions and to reduce further losses in biodiversity.

A forest climate monitoring program in highly altered landscapes needs to be co-located in the SI/MAB sites to understand the biometeorological exchanges and processes that influence biodiversity. Soil chemistry analysis, studies of a wide variety of biotic and abiotic components, tree ring analysis and proportional abundance analysis all greatly add to the shared insights from these biodiversity monitoring sites.

Adaptation scenarios in newly planted sites, mature forest sites, and managed and unmanaged sites need to be tested across a network of climate change experimental sites across the country.

3.4. Monitoring Designs

3.4.1. Paired Plots and Community Monitoring

Many agencies commonly establish at least two SI/MAB plots. One serves both for demonstration and training; the other is surveyed, staked and set aside for future research.

This design has worked well in the Niagara Escarpment. Plots established in the northern, central and southern areas of the escarpment by ACER provide a natural gradient of biodiversity and climatic conditions for studies of comparative monitoring on a regional scale. Pairing research and community-based plots helps to generate comparable and compatible data, enabling both scientists and community volunteers to learn how human impact affects local biodiversity. In addition, scientists can compare the effects of human impact on the community plots to that in the research or control plots.

By their very participation, local volunteers encourage the involvement of other community members to support plot monitoring over the long term. It has been shown that the greater the number of enthusiastic local volunteers, the greater the chance that the plots will be maintained and monitored to provide timely and useful information on changing local biodiversity. Moreover, because local citizens know the history of the area, they often notice small changes in the landscape more readily than visiting researchers.

Data collected by scientists or trained volunteers is first audited and validated before being exchanged locally, regionally, nationally and globally. It has been demonstrated that when scientists use and publish the data collected by local volunteers and students, citizens are motivated to do even more. In addition, meeting the scientists at the site gives the volunteers the opportunity to ask technical questions regarding biodiversity, climate change and other ecological issues in a friendly environment.

Monitoring sites can also be chosen using an analog approach – for example, establishing pairs of biodiversity sites in Washington, D.C., and

Toronto's Humber Arboretum to compare tree growth and survival across two growing zones equivalent to the distance that trees might be expected to shift under climate change.

Demonstration sites corresponding to either paired plot or analog designs are necessary to accurately evaluate surprises in adaptation responses to climate change: planning "on paper" is an unrealistic approach to understanding the realities of adaptation.

BOX 12

Gaps: Monitoring designs

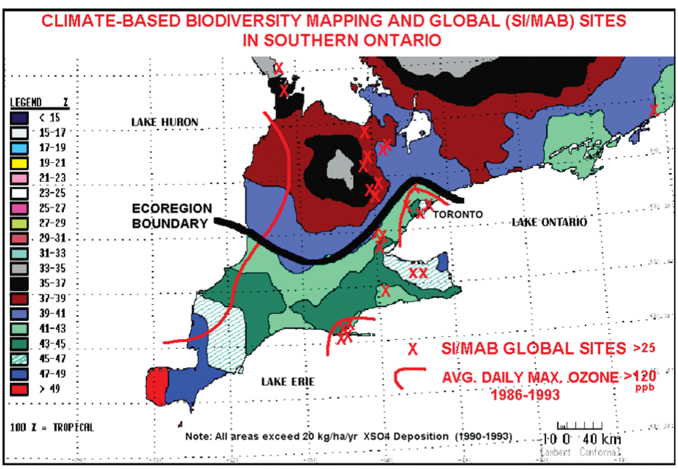
To date, there has been scant scientific interest in setting up research programs with paired plots. More financial resources are needed for the establishment and re-measurements of key paired research and community sites within the network.

Community monitoring and measuring needs to be adopted by more groups. More training is required for community groups in data entry and data validation. Connections need to be established between monitoring and measuring groups across the country. Financial resources should be made available to support community monitoring and measuring initiatives.

3.4.2. Transects

In Ontario, analysis has shown the tremendous value of using transect studies in evaluating climate impacts on biodiversity. One of the most distinct forestry transition zones in southern Ontario is the Carolinian zone in the Lake Erie Lowland eco-region. Above this zone is the Great Lakes-St. Lawrence Forest Region, which has markedly different forest biodiversity at the ecosystem, species and genetic levels. This major ecological zone occurs along a southern Ontario transect along and adjacent to the Niagara Escarpment from Wiarton at Georgian Bay to Long Point along Lake Erie.

It is possible to interrogate the relatively large number of SI/MAB sites (>25) in southern Ontario to show some of the tree species differences across this transect. Figure 62 shows an example from southern Ontario, where the transect of SI/MAB sites is layered onto a regional climate-based biodiversity map, along with the average daily atmospheric ground-level ozone measurements.



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 62. Cumulative impact of the chemical atmosphere

Climate-based biodiversity and SI/MAB observation sites

BOX 13

Gaps: Transects

There is a need to establish additional climate change/biodiversity monitoring sites across meaningful gradients to be able to model key climate variables such as temperature and drought frequency, both within and between bioregions, as well as nationwide.

3.5. Tools and Methods in Biodiversity Monitoring

The Smithsonian Institution and the UNESCO Man and the Biosphere Biological Diversity Program (now the Monitoring and Assessment for Biodiversity program) tested procedures for establishing permanent forest inventory plots in world biosphere reserves. The objectives of this program were to: 1) document plant diversity; 2) provide long-term data on the growth, mortality, regeneration and dynamics of forest trees; and 3) create a research and education base that will foster the conservation and management of biosphere reserves.

The Smithsonian Institution developed a monitoring protocol for establishing permanent plots for the long-term observation of biological diversity in forested areas (Dallmeier, 1992). For the first time, a globally standardized plot design has been adopted that is flexible and accommodating of different forest environments. This standardized design – a square, one-hectare plot (subdivided into 25 individual 20-by-20-metre quadrats) – allows compatibility and comparable reliability in data collected at different sites around the world.

The use of a one-hectare plot gives a relatively large sample and has been shown to be robust enough to capture the biodiversity of both a site in the tropics and in the Carolinian Zone of southern Ontario at its most biologically diverse. The protocol requires that all trees above a certain diameter (10 cm dbh in the tropics and 4 cm dbh in southern Ontario) are mapped, identified for species and measured for diameter at breast height (dbh) and total height (m). Parameters such as tree health, understory vegetation and other species may also be monitored in these sites using standardized protocols.

BOX 14

Gaps: Tools and methods in biodiversity monitoring

There needs to be greater follow-through once climate change/biodiversity monitoring sites are established and continued support for periodic re-measurements.

Standardized monitoring protocols in the context of international and global monitoring standards need to be developed and tested for: inland aquatic and semi-aquatic ecosystems; marine, estuarine and coastal ecosystems; native terrestrial species, communities and ecosystems; invasive organisms; and ecosystem processes (initial work was completed by the Canadian Biodiversity Science Board in the mid-1990s).

A "World Biodiversity Organization" or WBO needs to be created, paralleling the World Meteorological Organization (WMO), to design global standards and protocols for monitoring.

3.6. Administrative and Political Support: Will It Be Sustainable?

Canada is a signatory to both the CBD and the Cartagena Protocol on Biosafety. Canada has further responded to the issue of biodiversity loss by ratifying the CBD in Parliament, establishing a Biodiversity Convention Office in Environment Canada, producing a Science Assessment on Biodiversity and adopting the Canadian Biodiversity Strategy.

In signing the latter in 1995, all provinces and territories, as well as the Federal Government of Canada, "confirm[ed] on behalf of our respective governments that we are committed to the conservation of biodiversity and the sustainable use of biological resources. We will use the Canadian Biodiversity Strategy as a guide to our actions and invite all Canadians to join with us in conserving Canada's biodiversity and using biological resources in a sustainable manner."

The Canadian Biodiversity Strategy outlines a vision, guiding principles and goals, and offers more than 100 recommendations for action (**www.cbin.ec.gc.ca/**).

Further information on the history of Canada's commitments, actions and international involvement in climate change and biodiversity issues is summarized in section 1.

BOX 15

Gaps: Administrative and political support: Will it be sustainable?

No one agency in Canada currently has institutional responsibility for the monitoring of climate impacts, including those relevant to biodiversity. The absence of such a body – a Canadian Action Network for Climate Change/Biodiversity Monitoring – or an attendant support mechanism seriously hampers Canada's ability to meet its expressed biodiversity commitments.

Canada has yet to fulfill its commitments made in 1992, as well as recommendations in the CBD expert technical document; nor has it responded to recent recommendations from the Royal Society or to the Expert Report from the Convention on Biological Diversity. Other issues associated with gaps in governance have been addressed in the white paper by Jungcurt et al., 2008.