LONG POINT WORLD BIOSPHERE RESERVE

Monitoring Program
User Guide - 2003

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Abstract

After the 1992 Earth Summit in Rio de Janeiro, many international agencies recognizing the need to document changes in biodiversity began to establish biological monitoring programs. In Canada, the Ecological Monitoring and Assessment Network (EMAN) was formed in response to this need and began to focus on establishing standard methods for long term biodiversity monitoring across different forest types. At the same time, the Smithsonian Institution, in conjunction with the United Nation's Man and Biosphere Program (SI/MAB), were developing a standard method for establishing and cataloguing tree species in research plots within tropical biosphere reserves. The agencies collaborated in this endeavour and the SI/MAB protocol was adopted as part of a long term monitoring program being established in the Long Point World Biosphere Reserve (LPWBR) starting in 1995.

This was a community-based project completed with limited funding. Plot establishment, data collection and the user guide preparation relied on the expertise and enthusiasm of community members, university, college, high school and elementary students. This user guide is a compendium of information on the monitoring protocols being used in the Long Point World Biosphere Reserve Monitoring Program and is meant to guide future plot reinventories, data management, and program expansion.

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Introduction

The purpose of establishing a monitoring program at the Long Point World Biosphere Reserve is one of long-term data collection. The purpose of this report is to provide detailed documentation of the methods used for data collection and the subsequent analysis of the baseline data. This document serves as a user guide to facilitate monitoring reinventories and the appropriate expansion of the monitoring program. First a summary of the monitoring program at LPWBR is given. This is followed by a brief description of the monitoring sites and extensive documentation of the protocols used. Manuals for each protocol along with all the data collected are included in an accompanying CD. It is our hope that other biosphere reserves in Canada challenged with developing monitoring initiatives may benefit from the approach we have taken.

A Summary of the LPWBR Monitoring Program

In 1995 the Long Point World Biosphere Reserve instituted an environmental monitoring program. Three environmental factors, forest health, air quality and water quality have guided the development of the LPWBR monitoring program. Because of their dominance, trees (along with shrubs and ground cover in some instances) are being monitored to detect changes in forest health, while lichens due to their sensitivity to pollution levels are being used to assess air quality. Likewise, salamanders are responsive to local changes in habitat, acid rain, sedimentation, and contamination, while monitoring aquatic benthic invertebrates will tell us about water quality and how it may be changing. Over time, the suite of indicators measured in and around the plots will likely continue to increase as resources allow.

To date, the LPWBR monitoring program has focused predominantly on the establishment and (re) inventory of permanent forest biodiversity monitoring plots. These SI/MAB plots function as nodes around which to establish other monitoring protocols i.e. trees, shrubs, ground vegetation, salamanders, lichens, and to a lesser degree benthic invertebrates. Initially, four SI/MAB permanent forest biodiversity monitoring plots were established to collect baseline data on trees, shrubs, and ground vegetation. More recently in 2003 another forest biodiversity monitoring plot, modelled after the EMAN Terrestrial Vegetation Monitoring Protocol, was established. The baseline data collected during the original surveys, in 1995 for Backus Woods and Wilson Tract, 1996 for the Turkey Point area, and 2003 for Spooky Hollow, serves as a reference point against which to compare results of future sampling periods.

Over the years the LPWBR's monitoring program has expanded not only in geographical coverage but in ecological coverage as well. In 1998 the LPWBR initiated a salamander monitoring program at two of the forest monitoring plots (Backus Woods and Wilson Tract). The monitoring program was further expanded in 2003 to include lichen monitoring at four of the five sites (Backus Woods, Wilson Tract, Turkey Point 2, and Spooky Hollow). In co-operation with the LPRCA, the LPWBR also began a benthic invertebrate monitoring program under the auspices of the newly formed Ontario Benthos Biomonitoring Network.

Ultimately, this monitoring data and associated analysis will provide insight as to the causes and impacts of change and can serve an important function in defining research priorities (to explain causes of change). With an aim to collect data over a long period of time, the monitoring indicators will serve as early warning measures for noting ecological changes (e.g. rapid/high tree mortality). If significant changes occur from one sample period to the next, further investigation (by the appropriate authorities) as to why this is occurring would be warranted.

Site Selection and Establishment of SI/MAB Plots

As of 2003 the Long Point World Biosphere Reserve Foundation (LPWBRF) has established five permanent sample plots within the Long Point Biosphere Reserve's zone of co-operation (Figure 1). The plots which follow the SI/MAB protocol (Backus Woods, Wilson Tract, Turkey Point Plot #1, and Turkey Point Plot #2) are 1 hectare in size. Of these, two (Backus Woods, Wilson Tract) are located on property owned by the LPRCA while the other two are located on property owned by the provincial government (Turkey Point Provincial Park). The EMAN protocol plot in Spooky Hollow is composed of 21 20x20 m quadrats, which are dispersed across the LPRCA's Anderson Tract property and the HNC Spooky Hollow Nature Sanctuary. These locations were chosen because each is representative of the principle forest types in the Long Point region. Because the sample plots are located on property owned by conservation-oriented agencies, the future risk of direct human disturbance is minimal.

Figure 1: Monitoring Sites in the Long Point World Biosphere Reserve

Monitoring Site Descriptions

A brief description of each of the monitoring sites follows. Detailed information on the geology, soils, history, flora and fauna of each of the study areas can be found in *Long Point World Biosphere Reserve Monitoring Program Site Report* (Parker *et al.* 2003).

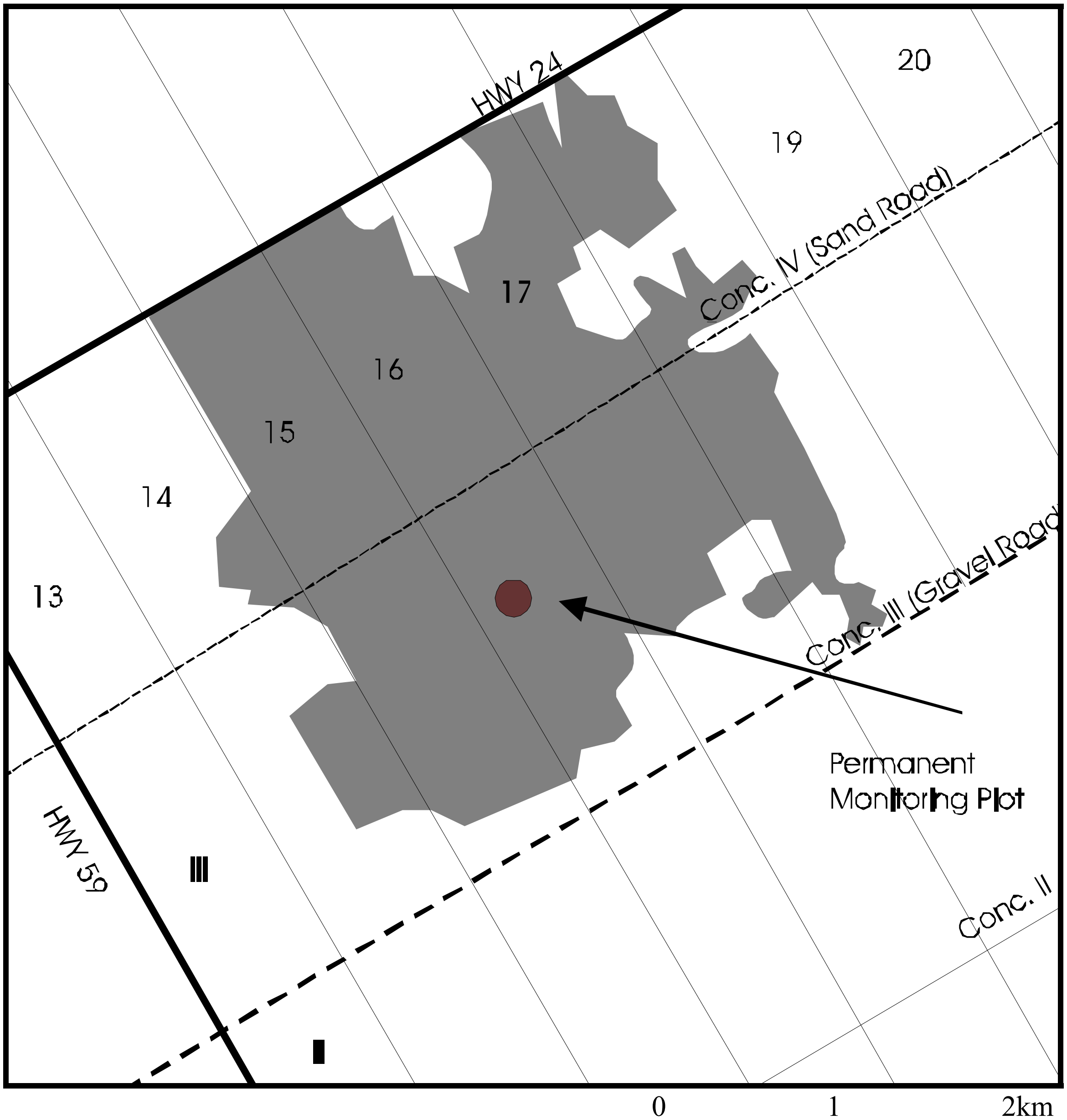
Backus Woods

The Backus Woods plot is an Old Growth Carolinian forest (upland hardwood) consisting mainly of oak and maple species. Most of Backus Woods has been subjected to little or no logging in the past 20 years; some areas have not been logged during this century. It is comprised of 491 ha of land, owned primarily by the Long Point Region Conservation Authority (LPRCA), the Regional Municipality of Haldimand Norfolk and some small private landholders. The forest is located entirely within the Township of Norfolk.

The SI/MAB forest monitoring plot was established in 1995 and reinventoried in 2000 and 2003. Currently, trees, lichens, and salamanders are monitored at this site. Shrubs surveys and vegetation studies for this site were completed in 1995. Figure 2 shows the size of Backus Woods and the location of the monitoring plot. Elevation profiles for all plots can be found in Appendix A.

The Backus Woods plot (42º 39.417' N, 80º 29.33' W) is most easily accessed from Hwy 24 by heading south on Hwy 59 until you reach Concession 4 (sand road) at approximately 1.5 km. Turn left heading east into Backus Woods. About 1.7 km in you will come up a sign with an accompanying trail that transects the sand road. Park here and follow the trail south. At the second branch take a right at the Black Gum signage and continue on for a ~200m. When you see a tree marked with flagging tape head SW cross-country for a 100m or so until you reach the plot.

Figure 2: Location of SI/MAB Plot in Backus Woods



Wilson Tract

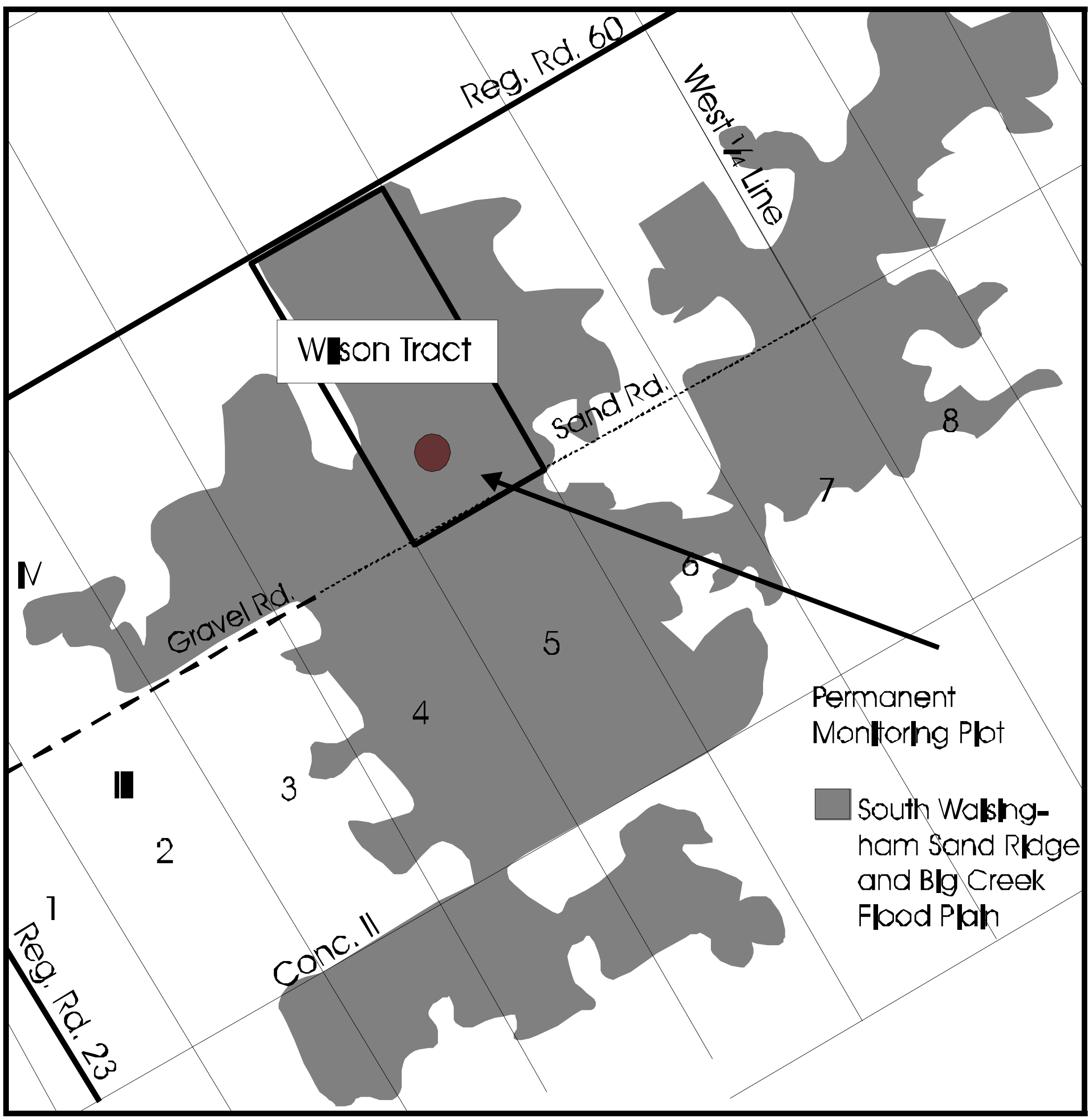
The Wilson Tract is typical of a "Managed Carolinian" forest comprised of upland hardwood and dominated by oak and maple species. Most of this area has been subjected to periodic timber and fuelwood extraction over the years. It is located within the South Walsingham forest, a 729 ha area of forested sand ridges including a portion of the Big Creek Flood Plain. The Wilson Tract, where the plot is located (Figure 3), is a 86 ha parcel of land owned by the LPRCA. Other portions of the forest are owned by: LPRCA, the Regional Municipality of Haldimand Norfolk, the Norfolk Field Naturalists and many private landowners.

The SI/MAB forest monitoring plot was established in 1995 and reinventoried in 2003. Currently, trees, lichens, and salamanders are monitored at this site. Shrubs surveys and vegetation studies for this site were completed in 1995. Having monitoring sites in

Wilson Tract, a managed Carolinian forest, and Backus Woods, a virtually natural Carolinian forest, affords opportunity for comparison.

Wilson Tract plot (42º 38.05' N, 80º 33.75' W) is accessed by continuing west on Hwy 24 until it turns into Hwy 60. At the 3.5 km mark turn south onto the unpaved road marked W Quarter Line. At the stop sign turn right (west) and drive for another 900 m. From here, hike north on the trail leading into the forest. Keep an eye out for a smaller trail leading off to your left. After this turn walk about 100 m where you will see another trail leading off to your left towards the Bioclimate Tower. When you reach the tower head up northeast over the hill. At about 20 m you will enter the plot.

Figure 3: Location of SI/MAB Plot in Wilson Tract



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Turkey Point Plots

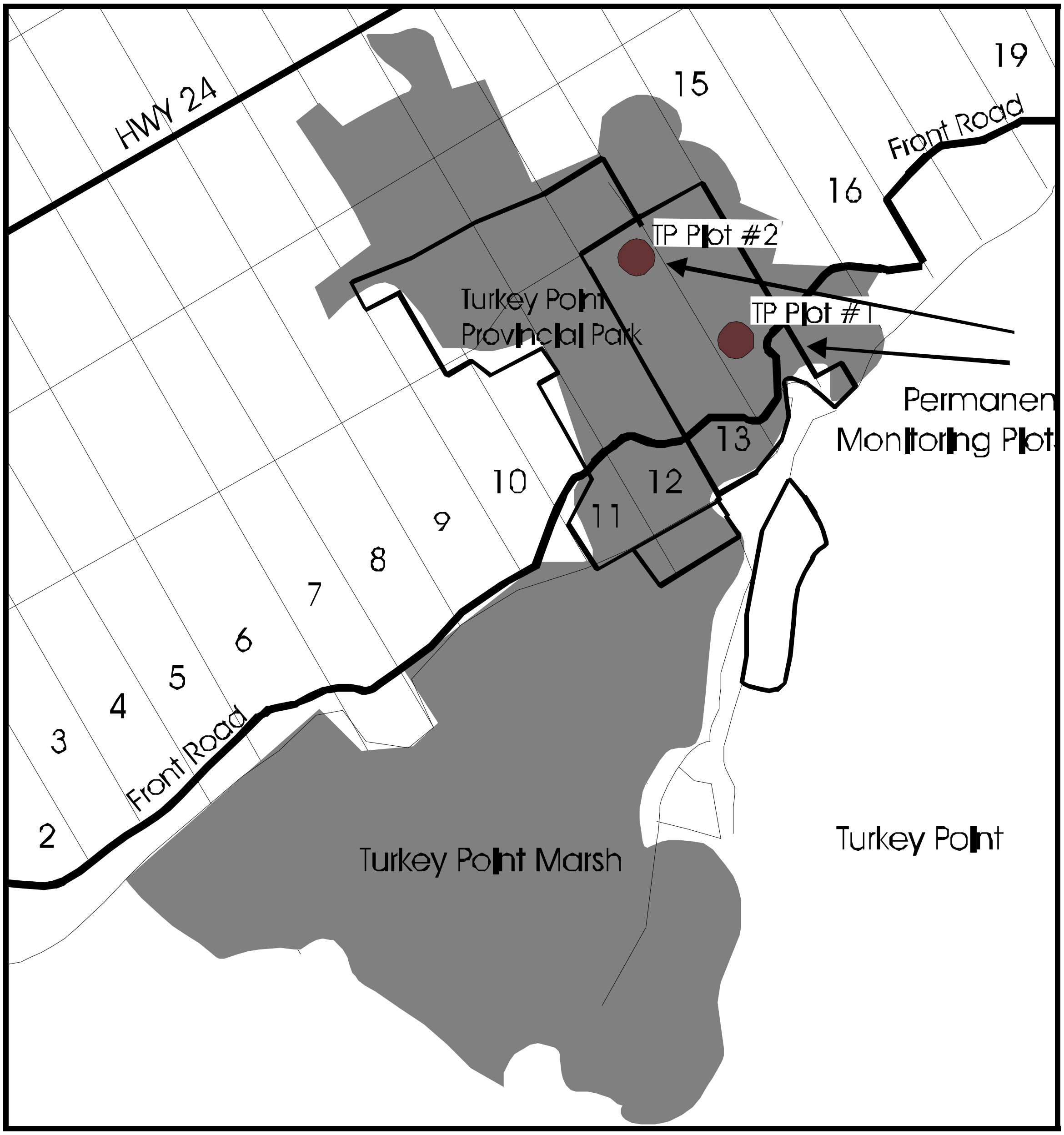
Located on the Norfolk Sand Plain, the Turkey Point Natural Area is subdivided into two categories: the sand spit region, and the area above the bluffs to the north. Two plots are located within Turkey Point Provincial Park, which is north of the bluffs. Plot #1 is characterised as Disturbed Oak Parkland. This plot was subjected to a prescribed burn in 1993 and was a campground prior to 1977. Plot #2 is in Oak Parkland that is in a relatively natural state. The Turkey Point Natural Area (2,325 ha) is owned in part by the Ontario Ministry of Natural Resources, the Regional Municipality of Haldimand Norfolk and some private landowners. It includes Turkey Point Marsh, the St. Williams Forest Station, the Normandale Fish Hatchery, as well as Turkey Point Provincial Park. Due to the variety of owners, this natural area has been subjected to a number of disturbances including construction and operation of park facilities, visitor activities, beach development, and the cottage and tourism industry.

These SI/MAB forest monitoring plots were established in 1996 and reinventoried in 2003. Currently, trees are monitored at both sites, while lichens are only monitored at Turkey Point #2, due to the recent burn at Turkey Point #1. Shrubs surveys for these sites were completed in 1996. No ground vegetation studies have been done. These two plots were set up to compare the influence of the prescribed burn with the natural state of the surrounding forest. Figure 4 shows the location of Turkey Point Provincial Park, where the two plots are situated. Elevation profiles for the plots can be found in Appendix A.

To access Turkey Point Plot #1 (42º 42.2' N, 80º 20.083' W) from Hwy 24 head south on Regional Road 10 for approximately 4 km, and turn east into the entrance to Turkey Point Provincial Park. Take the first left after the entrance gate and follow for about 100 m. Just after the parking lot on the right-hand side there is an almost indistinguishable former road. From this point hike in ~300 m along the old roadbed. The plot is located on the right and marked with black-spotted orange flagging tape.

To access Turkey Point Plot #2 (42º 42.633' N, 80º 20.5' W) from Hwy 24 head south on Regional Road 10 for approximately 4 km, and turn east at the sign for the Normandale Fish Culture Station and keep to your left. About 600 m along you will see a small shrub marked with black-spotted orange flagging tape and hanging over the right shoulder of the road. From this point hike south ~150 m where you will see the plot marked with black-spotted orange flagging tape.

Figure 4: Location of SI/MAB Plots at Turkey Point



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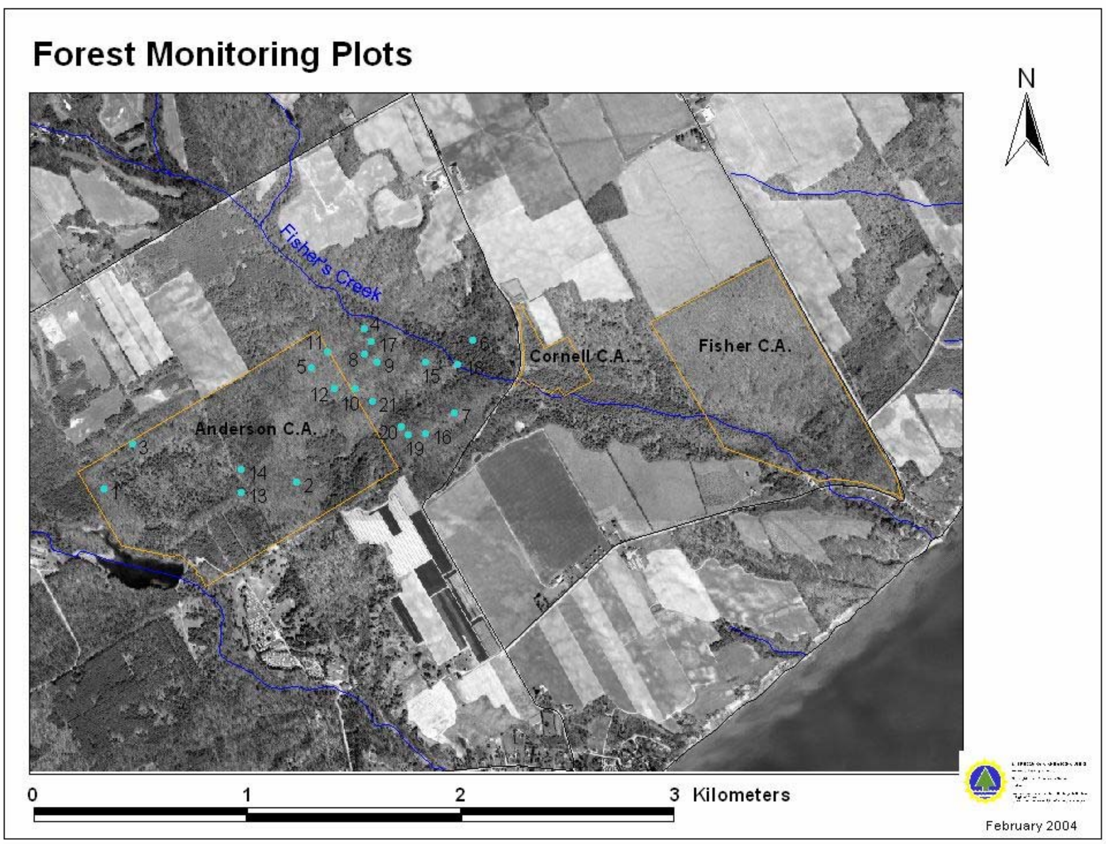
Spooky Hollow

The Spooky Hollow plot is a set of 21 quadrats dispersed across a variety of forest types (see Appendix B for specific plot locations) in the Spooky Hollow Natural Area. This contiguous area is approximately 333 ha in size and is made up of the Fisher-Cornell Conservation Area, the Anderson Tract and Spooky Hollow Nature Sanctuary. Properties in the area are owned by the LPRCA, the HNC as well as privately. Spooky Hollow contains very little mature forest other than the Eastern Hemlock forest along Fishers Creek. This creek is considered to be one of the most pristine in the region. Old fields, a product of historic agriculture in the Anderson Tract and surrounding private lands have been replanted in pine.

The EMAN forest monitoring plot was established in 2003. Currently, trees and lichens are monitored at this site. Shrubs surveys and vegetation studies have not been completed for this site. Figure 5 shows the location of Spooky Hollow Nature Sanctuary where the quadrats are located. Information on plot location and establishment including latitude, longitude, elevation, and canopy height can be found in Appendix B.

To access Spooky Hollow (42º 43.478' N, 80º 19.067' W) from Hwy 24 turn south onto Spooky Hollow Road. At the stop sign turn right (west). Take your first left to continue on Spooky Hollow Road. When this road plunges down in the hollow you will soon pass over Fishers Creek. Immediately after the creek on the right side (north of the road) is a small parking lot and the entrance to Spooky Hollow Nature Sanctuary where the quadrats are located. Some quadrats are more easily accessed by continuing on past this parking lot and up out of the hollow. At the first field there is space for parking on the right hand side of the road. From here hike along the north edge of the field heading west until you arrive at a trail leading into the Anderson Tract.

Figure 5: Location of EMAN Plots at Spooky Hollow



Description of Monitoring Protocols

In this section the monitoring protocols employed in the LPWBR monitoring program (forest biodiversity, salamanders, lichens, and benthic invertebrates) are described in detail. Metadata and methods for data management and analysis are included for each protocol. General time and labour budgets are also included. Each protocol summary is supplemented by the original protocol manual, which is in digital form on compact disc in Appendix C. The disc also contains all of the data that has been compiled from the LPWBR monitoring program and copies of accompanying reports: *Long Point World Biosphere Reserve Monitoring Program Site Report; Long Point World Biosphere Reserve Monitoring Program User Guide; Long Point World Biosphere Reserve Monitoring Program 2003 Status Report.*

Terrestrial Vegetation Monitoring Protocols

The tree inventory techniques used by the LPWBR generally follow the Smithsonian Institution's method for establishing and inventorying SI/MAB permanent plots as described in Dallmeier (1992). However, the most recent dispersed plot set up in Spooky Hollow is modelled after the EMAN Terrestrial Vegetation Biodiversity Monitoring Protocols (Roberts-Pichette and Gillespie, 1999). All inventories of the shrub and herbaceous layers also follow the EMAN Terrestrial Vegetation Biodiversity Monitoring Protocols.

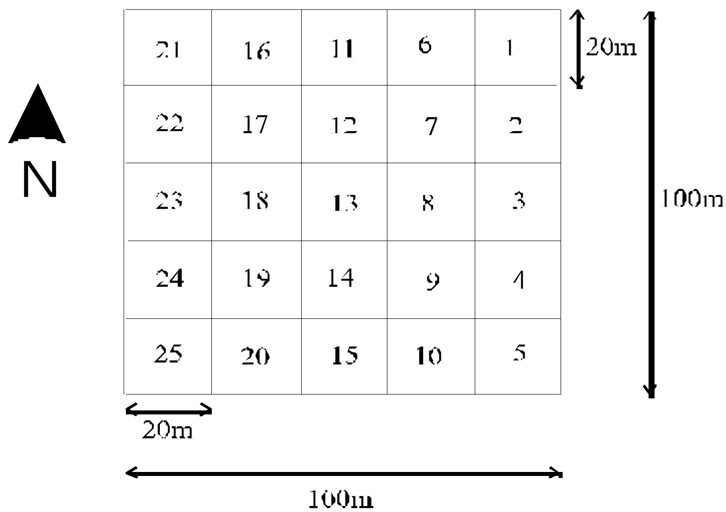
Plot Establishment

Backus Woods and Wilson Tract were surveyed in August 1995 by a local surveying firm. Turkey Point Plot #1 was surveyed in spring of 1996 by a local surveying firm while Turkey Point Plot #2 was surveyed by LPWBRF staff in August 1996. These plots are square, one hectare in size, 100 x 100 m (Figure 5) and were surveyed using a Total Station instrument. The dispersed Spooky Hollow plot was surveyed in August of 2003 by LPWBRF staff using a hand-held global positioning system, range finders, and compass.

A Total Station instrument (an electronic distance measuring device used to measure lengths as well as horizontal and vertical angles) was set up at each plot and tacheometric observations were made at the appropriate traverse stations by crews of two. The Backus Woods and Wilson Tract plots have 1 in^2 x 4 ft long solid steel bars placed at each of the corners. Within this 100 x 100 m plot, the 20 x 20 m quadrats were staked out at the corners with 1 in x 2 ft long round aluminum tubing. The corners of the Turkey Point plots and each of the 20 x 20 m quadrats within the plots are marked with 2 in^2 x 2 ft long hollow steel stakes. The Spooky Hollow quadrats are marked at each corner with 2 ft long aluminium pigtail push-pins flagged with black-spotted orange tape. These pins will eventually be replaced by 1 in^2 x 2ft steel bars courtesy of the HNC. During sampling string is tied along the borders of the quadrats to help delineate their boundaries.

Figure 6: Schematic Layout of SI/MAB Plots in Long Point World Biosphere

Reserve



Tree Monitoring Methodology

The trees within the four permanent biodiversity monitoring plots were sampled according to the method described by Dallmeier (1992) (see EMAN Terrestrial vegetaion monitoring protocol on CD in Appendix C). The only modification was the use of aluminum identification tags instead of red spray paint. The tags were attached to the trees at a height of 1.3 m using aluminum nails. The nails were angled upwards so that the chance of removal by falling limbs was reduced. The length and direction of fallen trees were also measured and recorded, although in recensus and new plot establishment (Spooky Hollow) direction was noted on the quadrat map but length was not. Trees were defined as woody plants with a diameter-at-breast (dbh) height greater than or equal to 0.04 m. Dbh measurements were recorded for all stems $0.04 m. It should be noted that when multiple stems occurred on the same tree, the largest stem should have been, but was not always, tagged as stem 'A'.

Shrub Monitoring Methodology

The protocol for mapping shrubs was developed in co-operation with EMAN. Shrub species were classified as woody plants with a diameter at breast height (dbh) of less than 0.04 m but greater that 0.01 m. Documentation of shrub species was carried out using two different sampling methods within each plot. Both methods, the Belt Transect and the Knight's Move are described in detail in Appendix D. The EMAN Terrestrial Vegetation Biodiversity Monitoring Protocols provide a variety of methods to determine quadrat arrangement based on community type (see EMAN Terrestrial vegetaion monitoring protocol on CD in Appendix C).

Ground Vegetation Monitoring Methodology

The protocol for surveying ground vegetation was also developed in co-operation with EMAN. The ground vegetation or herbaceous layer was classified as plants, shrubs and seedlings less than or equal to 1 m in height. For the purpose of this study, two methods of sampling were used. The first made use of a 1 x 60 m belt transect, while the second required the creation of 2 x 0.5 m sub quadrats within each quadrat (Appendix E).

Ground vegetation surveys were completed over a short period of time during the spring. Identification of some species that flower later in the growing season would have required additional surveys, but this was not logistically possible for the project. Future ground vegetation inventories will be performed at the same time of year to ensure that subsequent comparisons of ground vegetation biodiversity to the baseline data, presented in this user guide, will be consistent.

Data Compilation and Analysis

Since the objective of the biodiversity monitoring program is to record temporal changes in the forest community through long-term data collection, it is necessary to generate general statistical summaries for each of the plots. Analysing and comparing the results of inventories will allow us to determine the nature of change in the forest system.

Characterizing the nature of ecological change provides a starting place for understanding what may be occurring in the ecosystems within the Biosphere Reserve. However, determining causation and whether the change detected between reinventory periods is significant is exceedingly more difficult. Where possible significant thresholds based on theory and suggested reference levels from scientific literature have been established for the statistical analyses. These thresholds serve as a means of early warning and if exceeded will trigger further investigation as to the agent(s) of change. Each plot was selected to represent a specific forest type in the biosphere reserve therefore it is not appropriate to make comparisons between plots at different sites without careful consideration.

Statistical Analyses of Forest Inventory Data

The Biodiversity Monitoring Database (BioMon), developed by the SI/MAB Biodiversity Programme, was used to store and manage data collected from forest inventories. The data was collected and analysed, for each plot, and grouped by vegetation strata (ground vegetation, shrub and tree inventory) according to the EMAN Terrestrial Vegetation Monitoring Protocols (see pg 28 of this file on the CD in Appendix C). A brief summary is given below.

To begin a master species list was prepared (alphabetically by family and scientific name) for each plot making note of any species that were regionally, provincially, or nationally rare. Exotic species were likewise noted and rated using the Weediness Index developed by the National Heritage Information Centre (Oldham *et al.* 1995). Abundance, frequency, relative frequency and relative density were calculated for all live shrubs while abundance of ground vegetation was calculated for each plot. No estimates of percent cover were made for either the shrub or ground vegetation layers during these inventories. If estimates of percent cover for ground vegetation were done this would make inter-year comparisons of changes in relative cover possible.

Initial analysis of the tree inventory data was done using the BioMon software and included:

- **Census**: Summary of the trees in each status category.

- **Abundance**: total number of individuals of each species in the total area sampled. Summary table lists species in order of abundance (greatest to least) and includes scientific names.

- **Average dbh**: calculated for the stand as a whole (live trees only). Multiple stems were included in these calculations.

- **Distribution of dbh size classes**: the distribution of 5cm dbh size classes were worked up for dominant tree species on each plot.

- **Basal area**: the area occupied by a stem at dbh was also calculated for each of the tree species and for the plot as a whole. Multiple live stems were included in all basal area calculations.

- **Relative frequency**: the number of samples (quadrats) in which the species occurs as a percentage of all species in the plot.

- **Relative density**: the total number of trees of a particular species as a percentage of all the trees in the plot.

- **Relative dominance**: the basal area of a species as a percentage of the total basal area of all trees in the plot.

- **Importance Value Index (IVI)**: overall estimate of the influence of a species in a given ecosystem or community (Brower and Zar, 1984) by indicating which species exerted control over the structure and composition of the community.

Refer to Appendix F for descriptions of the formulae used to determine relative density, relative dominance, relative frequency and IVI. These were calculated for all live trees (dbh. 0.04 m or greater) in the Long Point monitoring plots. Only one stem, from trees with multiple stems was used in frequency and density calculations to ensure each tree was represented only once.

Diversity and Heterogeneity Indices

In addition to the relative measures calculated from the inventory data, measures of diversity and species heterogeneity were also calculated. Diversity and heterogeneity indices are often used as measures of environmental indicators because it is generally accepted that diversity will decrease with increased disturbance and pollution (Magurran, 1988). Diversity indices are based on the species present in a community and the abundance of species in the given community (Spellerberg, 1991). The following indices were used: Brillouin Diversity Measure and Brillouin-based Evenness Measure.

- **Brillouin Diversity Measure**: The concept of diversity relates to the distribution of observations among categories (Zar, 1984), specifically the number of observations of different species of trees with the SI/MAB plots. Because the data collected from the plots constitutes an entire population (i.e. every tree in the plot was identified and measured), the data was thus not considered to be from a random sample. In this case, traditional measures of diversity, such as the Shannon-Weiner Diversity Index are inappropriate. Therefore, the diversity measure of Brillouin was used (Zar, 1984).

- **Brillouin-based Evenness Measure**: The magnitude of the diversity measure is affected not only by the distribution of data but also by the number of categories (Zar, 1984). It is therefore possible to express the observed diversity as a proportion of the maximum possible diversity. A value of 0.1 represents a highly uneven distribution (where one species is dominant) whereas a value of 0.9 would indicate a very evenly distributed population (where the maximum value is 1). This calculation is termed evenness or homogeneity. Because the data obtained from the tree inventories constitutes an entire population rather than a sample, the number of categories (in this case, species) is therefore a known value rather than an estimate.

Only stem A of trees with multiple stems was included in calculations so that each tree was represented once. The Brillouin Diversity Measure, for tree inventories, was calculated using the BIO-DAP, which was developed at Fundy National Park and is based on Magurran (1988). The Brillouin-based Evenness Measure was calculated by hand (see Appendix F for formulae used).

Analysing Tree Mortality Rates

Reinventories of the established forest monitoring plots has allowed for temporal comparison and assessment of changes in forest biodiversity. Tree-death data has recently been used as a measure to determine long-term trends in forest health over a hierarchy of local, regional, and sub-continental scales (Loucks, 1998). Theory and field data suggest that in healthy deciduous forests annual tree mortality ranges from 0.4-0.8% (Loucks, 1995) and that small changes in mortality rate can induce large structural and compositional changes. Over a ten-year period we would expect to see 4-8% successional turnover, while over a hundred years this would amount to 40-80% of the forest. A doubling of the mortality rate (0.8-1.6%) would induce significant change in forest succession in terms of rates of turnover, biodiversity, age distribution and stand structure.

- **Tree Mortality Rate**: calculated as numbers of stems dying annually or as cross-sectional basal area lost per year. The amount of biomass lost due to tree mortality increases during succession up until biomass accumulation begins to level off when loss of biomass to annual tree mortality nears the total annual biomass gained due to tree growth. Mortality rate (%) can be expressed as the annual mortality increment of standing biomass over total standing biomass, a rate that should be relatively stable in old-growth forests.

Tracking mortality rates in the LPWBR monitoring plots and comparing these with rates calculated for floristically similar forests and/or rates calculated based on historical data will enable us to describe to what degree forests processes are changing and whether this should be of concern. Tree inventory data was exported from the BioMon program into Microsoft Excel® where it was cleaned and manipulated in order to calculate mortality rates. Methods for calculating tree mortality rates can be found in Appendix G.

Budgeting Time and Labour

Time and labour for the monitoring program can be broken down into three categories: fieldwork, data input, and data analysis. Estimates of the resources required for each are given below. These of course will vary somewhat depending on training and experience.

- **Fieldwork**: A team of two individuals should be able to complete a tree inventory for a one hectare plot in just over 40 hrs (80 work hrs). This estimate does not include time for training or establishing the plot. Experience establishing the 21 quadrats in Spooky Hollow suggests that each quadrat takes approximately 5 hrs to locate, set up, and inventory.

- **Data Input**: In total it took ~68 hrs to input all of the tree data from the 133 quadrats. This equates to about half an hour per quadrat.

- **Data Analysis**: Calculating the basic statistics in BioMon takes only a few minutes as does computing the diversity measures. Tree mortality rates are more intensive because of the large data sets that must be filtered and assessed. These calculations took upwards of 5 hrs, although future analyses should be somewhat faster now that a database has been developed.

Salamander Monitoring Protocol

Salamanders are an ideal monitoring indicator as they are territorial, found in high densities, easy to handle and responsive to local changes in habitat, acid rain, sedimentation, and contamination (Droege, 1997; EMAN, 2003b). Little information currently exists on salamander populations in Canada. The salamander monitoring occurring at the LPWBR is modelled after the soon to be released protocol under development by EMAN (EMAN, 2003c).

Plot Establishment

Salamander monitoring in LPWBR was linked to the forest monitoring plots by setting up artificial cover boards (ACO) around the perimeter of each forest plot (i.e. Backus Woods, and Wilson Tract). Monitoring has been ongoing since 1998 and consists of weekly surveys of at least eight weeks normally from spring thaw through until winter freeze up. Both the Backus and Wilson plots have two sets of perimeter boards. One set in each plot was placed directly on mineral soil while the other was placed on leaves. This was done so that a bias test could one day be conducted. 100 ACOs have been established in both Backus Woods and Wilson Tract.

Survey Methodology

The protocol consists of setting down a series of wooden boards adjacent to forest plots in order to provide cover for salamanders. Initial ACO placement consists of 40 boards arranged in a 20 by 20 meter quadrant (Zorn and Blazeski, 2002). Artificial cover boards of any type of wood can be used provided that it is consistent over time, and the board is flat and non-layered. The boards used in both monitoring plots are unfinished, untreated white pine. The relative size of the boards varies, however, the cumulative coverage of different sized boards is equal in both plots. These boards should not be placed closer to each other than five meters or within 50 meters of the edge of the forest

(Droege, 1997).

The boards are checked once every week, to minimize disturbance in the plot, for a minimum of eight weeks (monitoring in Backus and Wilson has been done for 24 weeks) sometime during the months of April to November excluding July and August. Salamanders (*Plethodon cinereus*) "captured" under each board are identified and measured. For each amphibian, snout to vent length (SVL), vent to tail length (VTL) and total length (TL) are recorded along with the date, ACO number and disturbance to ACO (if any). Over time this data will allow relative changes in abundance and morphology to be detected.

Data Compilation and Analysis

Monitoring data is being compiled to assess species presence and abundance as well as size in order to establish trends. There are two pilot questions that the salamander monitoring program is designed to answer is:

- Is an index of population size (counts) of plethodontids changing more than +/- 15% over a 5 year period or more than +/- 3% per year?
- Are there noticeable changes in the size of plethodontids over this same period?

Initially all data was compiled using the Excel© spreadsheet designed to accompany the National Monitoring Protocol for Plethodontid Salamanders (Zorn and Blazeski, 2002). To facilitate comparison, population counts were evaluated based on per day sampling effort (Van Wieren, 2003). Monthly, annual and a periodic 5-year count of salamanders found per day were established and compared to answer the first monitoring question. The monthly length averages (SVL, VTL, and TL) were calculated by averaging the length of all salamanders caught in the same month over the five years of data gathering. The air and soil temperature data from the Bioclimate Tower at Wilson Tract provided a means to correlate the abundance and size indicies with environmental variables. A more comprehensive description of data analysis can be found in *Long Point World Biosphere Reserve Plethodon Cinereus Monitoring Program: Data Analysis* (Van Wieren, 2003) on the User Guide CD.

Budgeting Time and Labour

Time and labour for the monitoring program can be broken down into three categories: fieldwork, data input, and data analysis. Estimates of the resources required for each are given below. These of course will vary depending on expertise available.

- **Fieldwork**: It took approximately one hour to check the hundred boards at each site. With an average of 40 salamanders encountered, monitoring of Backus Woods and Wilson Tract takes 2 hrs per week. Fifteen to twenty minutes may be added as the number of salamanders encountered rises to 80.

- **Data Input**: In total it took one hour per week to input all of the tree data from both Backus Woods and Wilson Tract.

- **Data Analysis**: The Plethodontid Protocol Datasheet automatically calculates the basic statistics used for analysis. More complex analyses will of course require more time.

Lichen Monitoring Protocol

Arboreal lichens (tree trunk dwelling lichens) are particularly good biomonitors, due to their sensitivity to environmental stress, especially air pollution, eutrophication, and climate change (Asta *et al*. 2002; Richardson, 1992). The lichen monitoring undertaken by the LPWBR follows the *Protocols for Monitoring with Lichens* in development by EMAN (EMAN, 2003a).

Plot Establishment

Lichen monitoring in LPWBR was linked to the forest monitoring plots by carrying out the lichen protocol within the four corner quadrats (1, 5, 21, 25) of each forest plot (i.e. Backus Woods, Wilson Tract and Turkey Point #2). At Spooky Hollow where this was not possible the lichen protocol was carried out across the area in selected quadrats (1, 7, 10, 11). A total of 16 quadrats were sampled for lichens.

Lichen Survey Methodology

Two separate methods were used to assess arboreal lichen abundance and diversity: Ladder Method and Photometric method.

Ladder Method

The Ladder Method involved selecting the four largest trees in each quadrat for lichen sampling. The sample sites for lichen monitoring were previously recorded during establishment of the forest biodiversity monitoring plots. At each sample tree general conditions were recorded: site terrain and aspect, tree sheltering and shading, lichen age and vitality. Trees with very little lichen present or damaged were discarded and replaced by the nearest suitable individual. Any such changes to the method should be noted. A 10 x 50 cm ladder consisting of 5, 10 x 10 cm contiguous quadrats was placed on the four cardinal points (N, E, S, W) of each tree. Two stainless steel nails were secured into the tree at 1.5 m at each cardinal point, while a single ladder was moved from point to point during sampling.

A 10x hand lens was used to identify all lichens occurring within the five grid squares. The handbook *Identifying Mixed Hardwood Forest Lichens* (Brodo and Craig, 2003) was the main source used for species identification (see Brodo in Additional References as well). All lichen species and the number of steps of the ladder in which the species occurs was recorded. The trees selected for monitoring are listed in Appendix H.

Photometric method

This method was pilot tested at the LPWBR. The method relies on taking a series of standardized photographs of an arboreal lichen community over time to assess changes in lichen size, shape, and colour. Trees for this protocol were selected based on the abundance of an easily identified group of lichens at the standard 1.5 m height. Larger trees are preferred so as to limit difficulties with curvature and obtaining sufficient depth of field. The lichens were encompassed by a standard framing device marked with scales on its sides and a digital camera was used to photograph them. Stainless steel nails were embedded in each sample tree so that the frame could be place in the same spot for future sampling. Image analysis software will be used to manipulate and analyse the images to determine areal change over time. Because this protocol is still under development and may undergo significant changes in the near future image analysis will be deferred until a future time. The trees selected for monitoring are listed in Appendix H.

Data Compilation and Analysis

Data compilation and analysis was greatly facilitated by the Lichen Protocol Datasheet. The datasheet provides a repository for all monitoring data related to the site, trees selected for monitoring and the lichens sampled. Lichen Diversity Value (LDV) and Lichen Diversity Class Width were calculated for each site. See *European Guideline for Mapping Lichen Diversity* (This is the program on which the Draft *EMAN Program: Protocol for Monitoring with Lichens* is being based) on the CD in Appendix C for a full description of the formulae.

- **Lichen Diversity Value**: The LDV is a measure of the lichen diversity in a sample unit, in our case a plot site. To start, add up the frequencies of all lichen species at each cardinal point on each tree. Each tree will have four sums of frequencies (SF). Next, calculate the mean of the SF for each cardinal point. LDV is equal to the sum of these four mean sum of frequencies (MSF).

- **Lichen Diversity Class Width**: The Class Width is equal to three standard errors of the Lichen Diversity Value, and is used to determine when a change through time is a significant change (threshold). If the LDV changes by a magnitude greater than the Class Width then the lichen community in that sampling unit has undergone a significant change. For example: In the 2003 inventory of Backus Woods the LDV was 17.3 while the class width was 2.2, therefore a change of >2.2 species would be necessary to be considered a significant change in the lichen community.

It is not appropriate to make comparisons between plots if sites differ greatly in topography or forest type. In future, LDVs may be plotted on geographic base maps and assigned to lichen diversity classes. Overlaying maps of meteorology and regional pollutant concentrations may provide insight into changes in LDVs.

Budgeting Time and Labour

Time and labour for the monitoring program can be broken down into three categories: fieldwork, data input, and data analysis. Estimates of the resources required for each are given below. These of course will vary depending on expertise available.

- **Fieldwork**: It took between 2-5 hrs (5-10 work hrs) for our team of two to establish and complete the arboreal lichen inventory on a quadrat of four trees. This also included carrying out the photometric method. Times decreased with experience identifying species, however, variable lichen diversity between trees is also reflected in the range of sample times.

- **Data Input**: In total it took ~12 hrs to input all of the tree data from the 64 trees. This equates to about 12 minutes per tree.

- **Data Analysis**: The Lichen Protocol Datasheet automatically calculates the basic statistics used for analysis.

Benthic Invertebrate Monitoring Protocol

Benthic invertebrates (large, bottom dwelling insects, crustaceans, worms, molluscs, and related aquatic animals) are good indicators of aquatic conditions because they respond relatively quickly to stressors (OBBN, 2003). The LPWBR benthic invertebrate monitoring program is designed according to the protocols set out by the newly founded Ontario Benthos Biomonitoring Network (OBBN). The OBBN, administered through the Ministry of the Environment's (MOE) Dorset Science Center, exists to facilitate the assessment of aquatic habitats using benthic invertebrates, thereby complementing the Provincial Water Quality Monitoring Network. The LPRCA has long been carrying out both water quality and benthic invertebrate monitoring in the Long Point area. In the fall of 2003 the LPWBR partnered with the LPRCA to expand upon this monitoring program using the new OBBN reference condition approach (RCA).

Plot Establishment

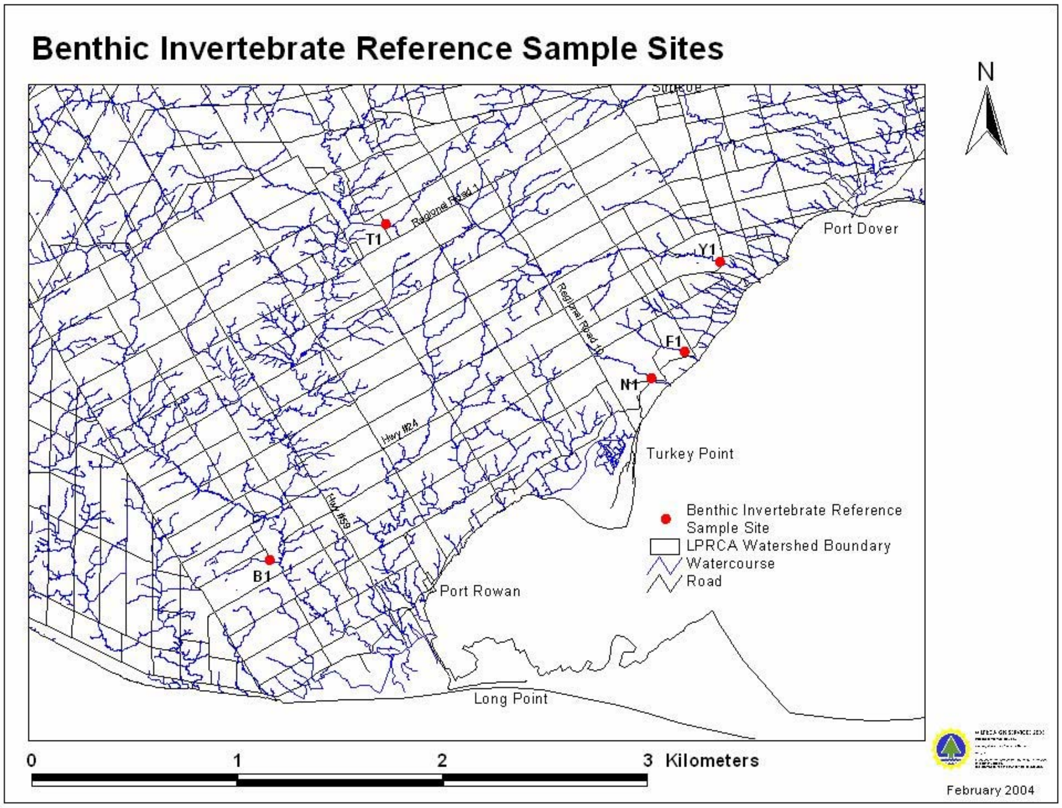
The RCA samples biological condition/variability of minimally impacted sites to establish the normal range of conditions to be expected at more impacted test sites (MOE, 2003). A list of criteria from the RCA, and outlined in Table1, was used to select minimally impacted watercourses and sites in Norfolk County.

Table 1: Criteria used to Screen Minimally Impacted Watercourses and Sampling Sites

Criteria for "Minimally Impacted"
Well downstream of significant point sources
Minimal regulation of water level (minimal affect from dams and impoundments)
Extensive naturally vegetated buffer
Well forested catchment
Minimal development or urban land use in catchment
Minimal agricultural land use in catchment
Minimal impervious cover and artificial drainage in catchment
Minimal anthropogenic acidification (i.e.pH matches expectation based on local geology)
Water chemistry better than regulatory guidelines, (e.g. MOE Provincial Water Quality Objectives)

Initially five sites within the LPWBR zone-of-cooperation were selected for sampling. These are shown in Figure 7 (actual coordinates for each site can be found in Appendix I).

Figure 7: Benthic Invertebrate Reference Sampling Sites



Key: B1-Beckers Creek, F1-Fishers Creek, N1-Normandale Creek, T1-Trout Creek, Y1-Youngs Creek

Benthic Invertebrate Survey Methodology

The RCA relies on sampling the benthic invertebrate community of least impacted streams in order to establish a normal range of variability for comparison with test sites. Sampling of reference sites followed the OBBN protocol in which a sampling reach was selected and then sampled at three adjacent locations. Physiographic information was compiled for each site with help from the LPRCA, while site and habitat characteristics were measured onsite. Sampling consisted of timed transect sweep samples across each location. These samples were picked to acquire a minimum of 100 invertebrates for each sweep sample (i.e. >300 count/stream site). Invertebrates were identified onsite to the minimum level of taxonomic resolution necessary for inclusion in the OBBN (i.e. a mixture of Classes, Orders, sub-Orders, and Families). These specimen samples were preserved and then sent to Chris Jones at the Dorset Science Center for further expert identification to the genus/species level. A complete overview of the sampling protocol is provided in digital form (see OBBN Protocol Manual on CD in Appendix C).

Data Compilation and Analysis

To date the benthic invertebrate data has been used to measure taxonomic richness, abundance and diversity of the five reference sites.

- **Taxonomic Richness**: Number of taxonomic groups found

- **Total Number of Individuals**: Total number of invertebrates in sample
- **Total Number of EPTs**: Total number of mayflies, stoneflies, and caddisflies
- **Percent Dominants**: Ratio of most abundant taxon to total number of individuals
- **Dominance-Diversity Curve**: Comparison of the most percent dominants

Future analysis will follow that laid out in the OBBN Protocol Manual. The benthic community at these reference sites will be characterized to establish a normal range against which test sites will be evaluated. A suite of critical index values based on the reference sites will be calculated along with their range of variation (based on two standard errors), which will allow us to comparatively measure the health of test sites. The two-step process will include a multivariate t-test to determine if a test site falls outside of the normal range. Subsequently discriminant analysis will be used to determine which indices best distinguish the test site from the reference condition.

Budgeting Time and Labour

To date only fieldwork has been completed. An estimate of the resources required for this component of the monitoring is given below. This of course will vary somewhat depending on training and experience.

- **Fieldwork**: It took between 2-3 hrs/site (4-6 work hrs) for our team of two to complete benthic sampling. Picking the collected samples and identifying the invertebrates (minimum 300 specimens) took approximately 5-6 hrs/site (10-12 work hrs). Each sample site takes about one full workday to complete.

Reporting Results

The LPWBR Monitoring Program is producing very valuable results that are being used to assess regional environmental health, design national environmental monitoring protocols, influence regional development, measure provincial forest health, and build/update local natural inventories. For the program to continue to effectively communicate its findings future reinventories and expansions should follow the standardized reporting guidelines outlined below.

The LPWBR Monitoring Program was established in 1995, reinventoried in part in 2000 and greatly expanded in 2003. Initially, reporting the monitoring results followed the approach taken by the SI/MAB Program, which included a Site Report and User Guide. However, with the expansion of the monitoring program over the last number of years has also come further sophistication in organizing and reporting results. Three documents with distinct purposes describe the LPWBR Monitoring Program.

- ***Long Point World Biosphere Reserve Monitoring Program Site Report*****:** This document summarizes the history and establishment of the LPWBR and its monitoring program. It also provides detailed information on the geology, soils, history, flora and fauna of each of the study areas. As the monitoring program expands to include more monitoring sites a summary for each site should be incorporated into the Site Report.

- ***Long Point World Biosphere Reserve Monitoring Program User Guide*:** The User Guide is designed to facilitate future sampling reinventories and monitoring program expansion by describing monitoring sites/efforts, the protocols used, useful contacts, and data analysis and management. All changes/expansions to the monitoring program, particularly involving protocols, must be described in detail and incorporated or appended to the User Guide so that practitioners are aware of these changes and are able to replicate the sampling procedures.

- ***Long Point World Biosphere Reserve Monitoring Program 2003 Status Report*:** The results of the LPWBR Monitoring Program inventory and reinventories are compiled and compared in this report. The Status Report is designed to provide a one-time update on the environmental status of the LPWBR. The initial 2003 Status Report is based on original 1995 inventory results, the Backus Woods reinventory in 2000, and the complete inventory as well as protocol expansion in 2003. Where possible temporal data is compared and changes are described. Future Status Reports should build on previous data analysis and reports but should be stand alone publications that provide the reader with an up to date, detailed account of the environmental status and change(s) within the LPWBR.

Practitioners will find it useful to prepare field guides that may include the protocols, maps, driving directions to the sites, data, and data sheets, necessary to complete monitoring reinventories. Preparing and using such field guides will ensure standardized sampling methods and efficient use of time in the field.

Data Management

The data has been organised and analysed in a manner that will allow future comparisons to be made among data collected at each plot. All the data is archived on the accompanying CD in Appendix C. To date all data analysis has been done using Microsoft Excel® and the Smithsonian Institution's BIOMON software. Due to the large number of practitioners that have been, and will likely continue to be, involved in the LPWBR Monitoring Program vigilance is required to maintain high quality data collection and management. Data checking measures should be followed for all new data entered and archived. Quality assurance and control will be ensured if the practitioner routinely carries out data checking during data entry, and the data is later reviewed by another individual. Data checking and review should be incorporated into the responsibilities of all employees or volunteers involved in data collection and management.

The organization of the User Guide CD provides the necessary framework to compile, manage and archive monitoring data and is easily expandable. All data collected should be compiled according to the standards laid out in the User Guide and properly archived on the accompanying CD (or CDs as the database grows). Pertinent contact people can be included in the contacts list in Appendix C, while the picture library on CD provides a repository of pictures and logos that can be used in publishing reports. An organizational guide to the User Guide CD is included in Appendix C.

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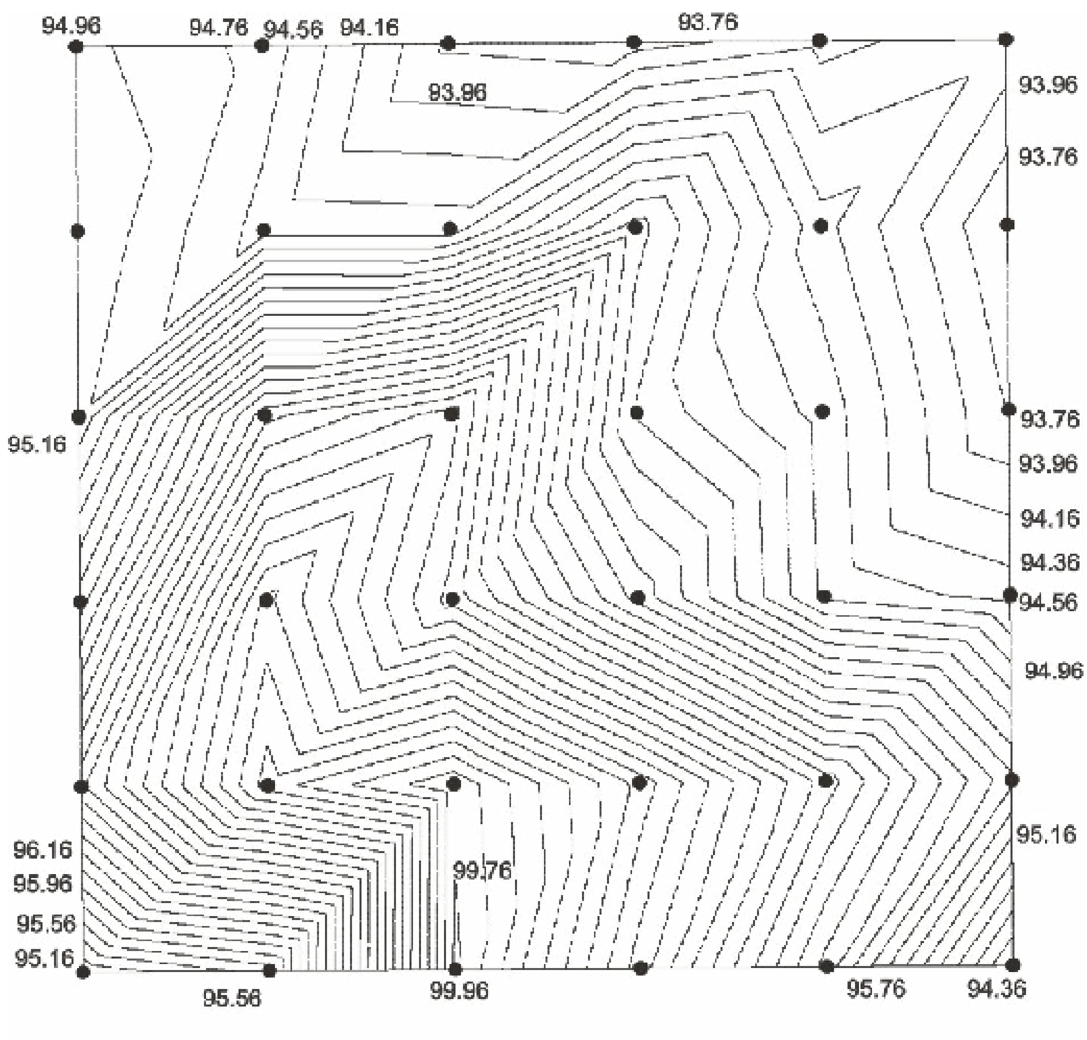
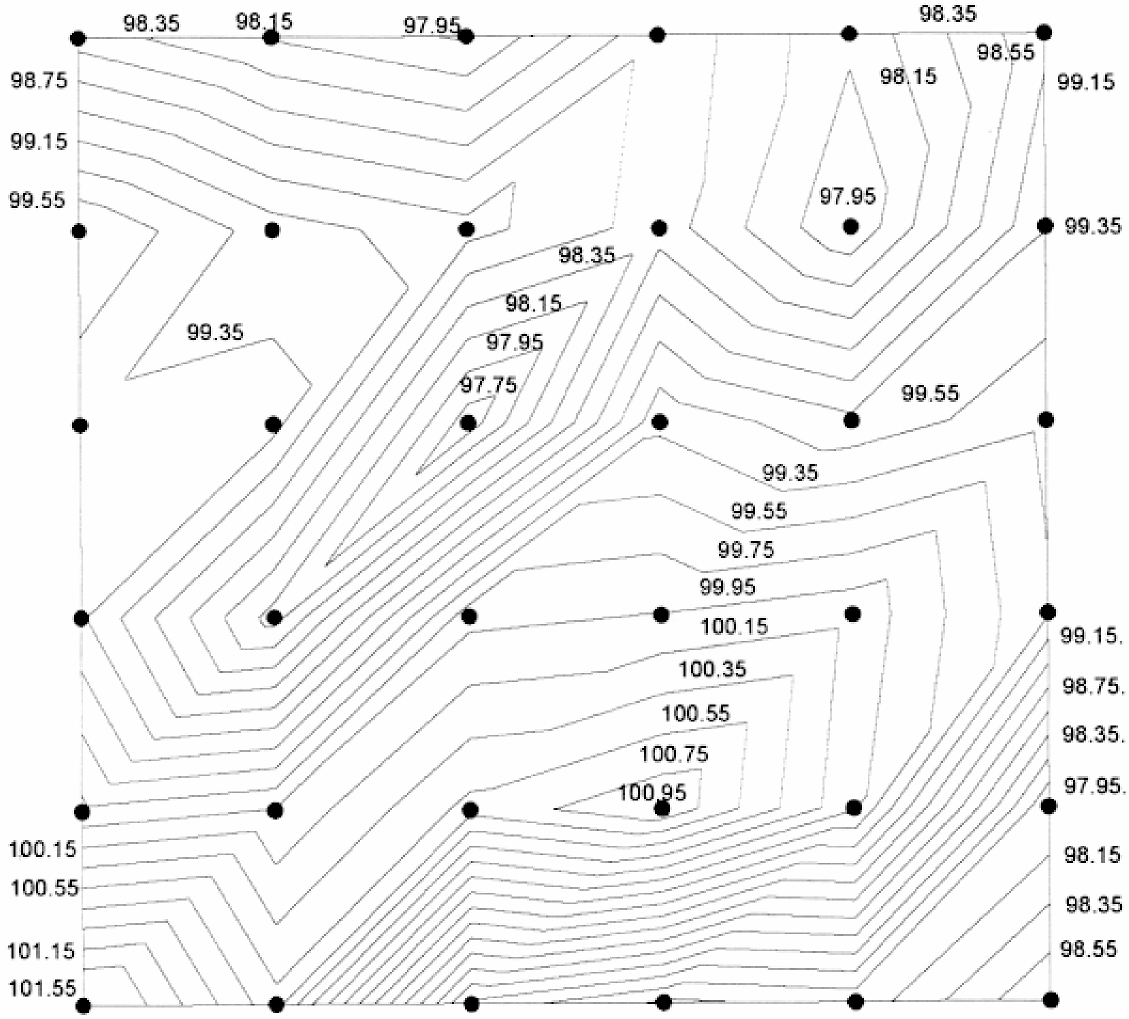
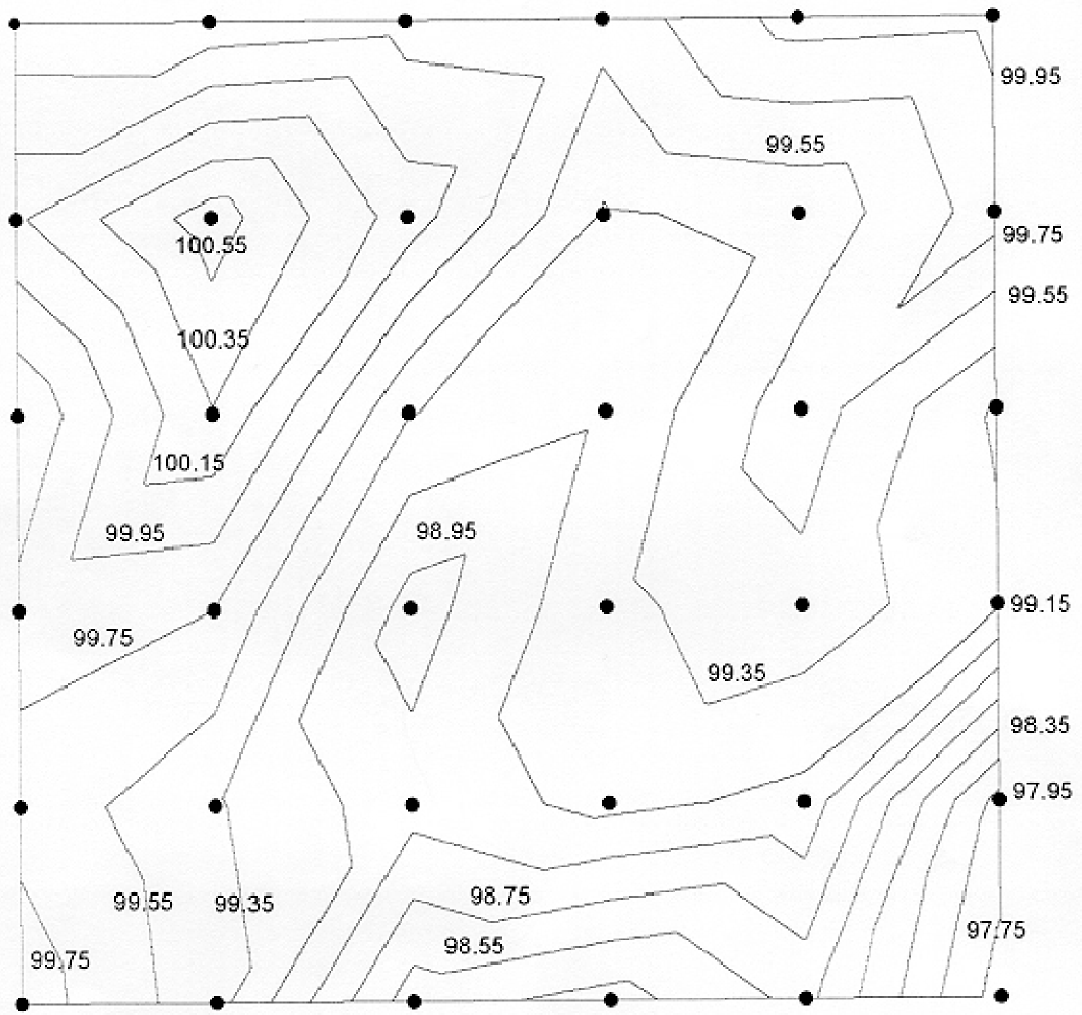
Appendix A: Elevation Profiles for Monitoring Plots



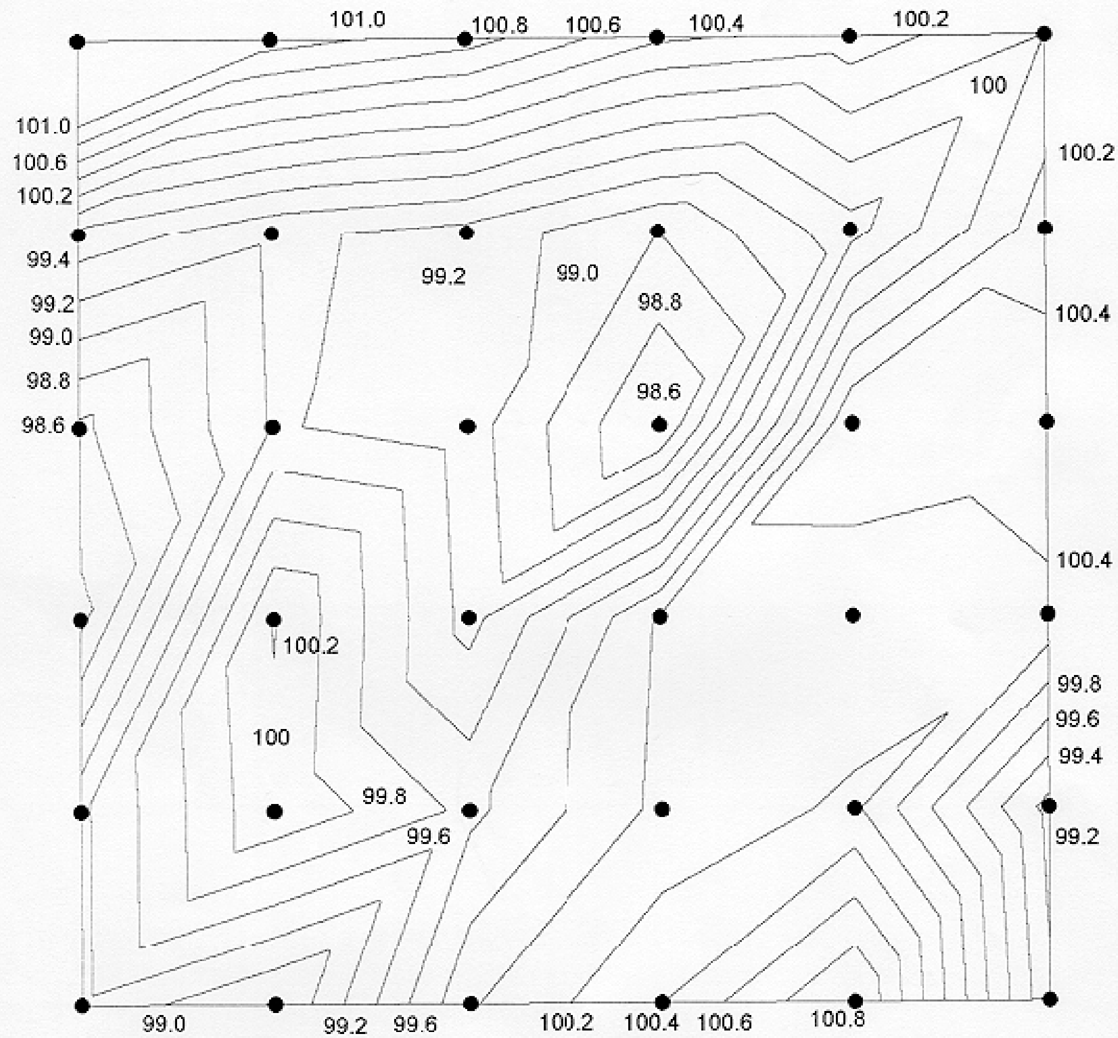
Backus Woods Plot Elevation Profile



Wilson Tract Plot Elevation Profile



Turkey Point Plot #1 Elevation Profile



Turkey Point Plot #2 Elevation Profile

Appendix B: Information on Plot Establishment at Spooky Hollow

Latitude, longitude and elevation were measured at the center of each quadrat using a hand-held Garmin 12 GPS Unit. The height of an average dominant tree within the plot was measured using a clinometer to obtain an estimate of canopy height.

Quadrat	Lat. (N-deg, min)	Long. (W-deg, min)	Elev. (meters)	GPS Accuracy (meters)	Canopy height (meters)	Notes
1	42º 43.306'	80º 20.169'	211	7.4	26	Found 78m W from edge of plantation
2	42º 43.320'	80º 19.567'	179	6.6	33	Moved 60 m NE to avoid trail
3	42º 43.412'	80º 20.080'	226	16.3	31	200m SW from cut area in pines
4	42º 43.672'	80º 19.352'	208.8	18.1	30	
5	42º 43.583'	80º 19.518'	237	13	25.5	
6	42º 43.647'	80º 19.008'	243	6.7	29	Quadrat is just NE of Fern Trail
7	42º 43.478'	80º 19.067'	251	7.6	31	In center of Marion Shivas Trail; garlic mustard onsite; bird nest in NW corner 13ft up in blue beech
8	42º 43.613'	80º 19.348'	221	8.9	20	
9	42º 43.599'	80º 19.308'	228	10	26	
10	42º 43.538'	80º 19.379'	208	14	26	Bird nest in NE corner 20 ft up in red maple
11	42º 43.618'	80º 19.462'	165	9.5	30.5	
12	42º 43.535'	80º 19.448'	Na	Na	Na	
13	42º 43.293'	80º 19.742'	245.9	6.5	25	
14	42º 43.347'	80º 19.743'	255.4	5.7	28	
15	42º	80º	197.9	13.7	36	

	43.593'	19.158'				
16	42º 43.425'	80º 19.158'	217.7	6.2	37	
17	42º 43.647'	80º 19.235'	226.8	7.3	28.5	
18	42º 43.59'	80º 19.055'	206	7.6	34	
19	42º 43.43'	80º 19.212'	237	12	44	
20	42º 43.447'	80º 19.237'	262	10.4	34	
21	42º 43.505'	80º 19.325'	259	10	37	

Appendix C: Contact List and User Guide CD

Contact organizations/individuals and useful web addresses:

Ecological Monitoring and Assessment Network
Brian Craig, Senior Science Advisor: (905) 336-4431 / brian.craig@ec.gc.ca
http://www.eman-rese.ca/eman/ecotools/protocols/terrestrial/

Long Point World Biosphere Reserve Foundation
Brian Craig, Director: (519) 755-5441 / longpointbio@kwic.com
http://www.kwic.com/~longpointbio/

Long Point Region Conservation Authority
Paul Gagnon, Lands and Waters Supervisor: (519) 428-4623 /
conservation@lprca.on.ca
http://www.lprca.on.ca/

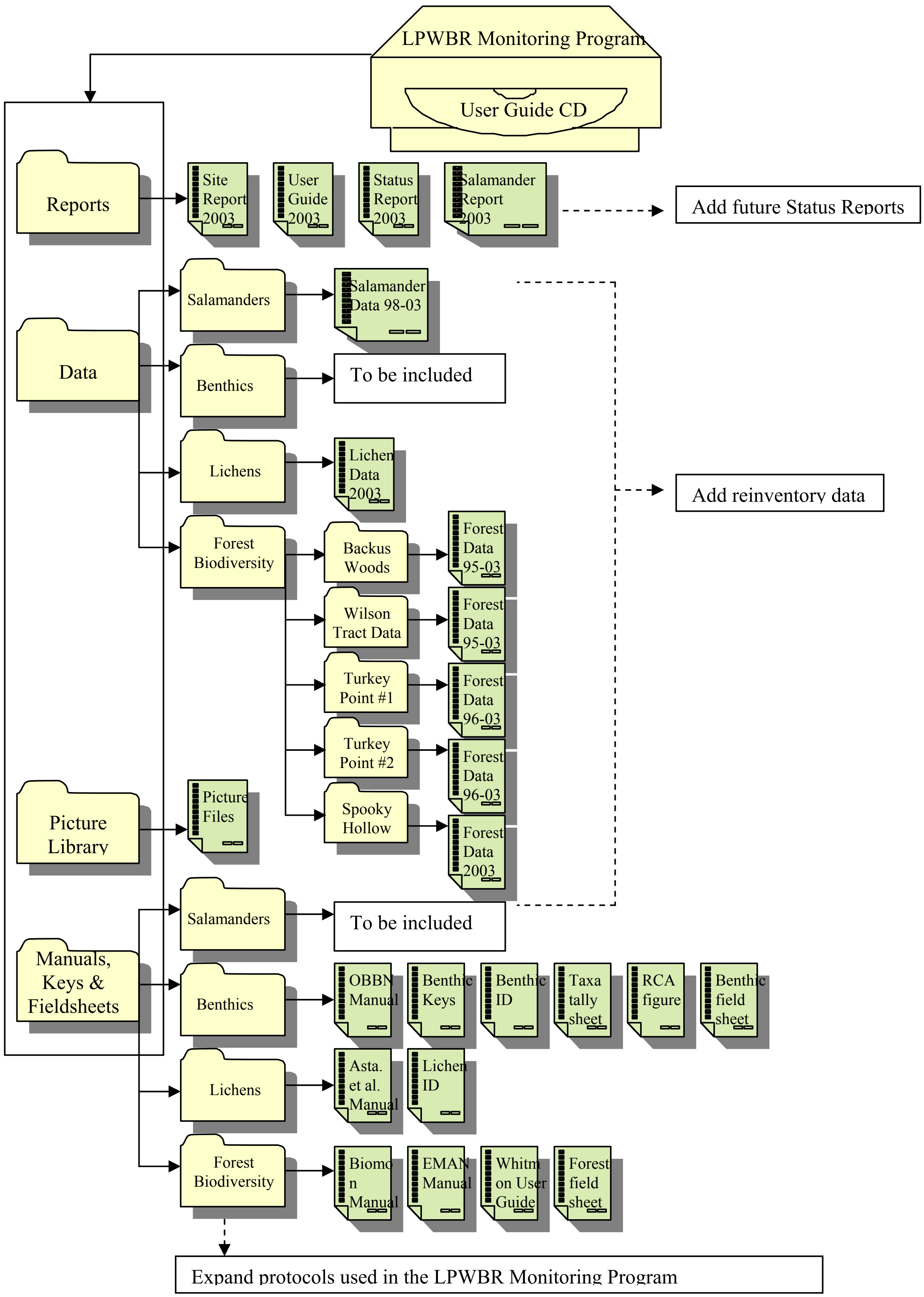
Turkey Point Provincial Park
Mike Postma, Superintendent: (519) 426-3239
http://www.ontarioparks.com/english/turk.html

Hamilton Naturalists' Club
Warren Beacham, Director: (905) 627-3343 / wbeach808@sympatico.ca
http://www.hamiltonnature.org/index.html

Smithsonian Institution's Monitoring and Assessment of Biodiversity Program
Franciso Dallmeier, MAB Director: (202) 357-4792 / fdallmeier@si.edu
http://nationalzoo.si.edu/ConservationAndScience/MAB/aboutmab/

Ontario Benthos Biomonitoring Network
Chris Jones, Benthic Biomonitoring Scientist: (705) 766-1724 /
chris.jones@ene.gov.on.ca

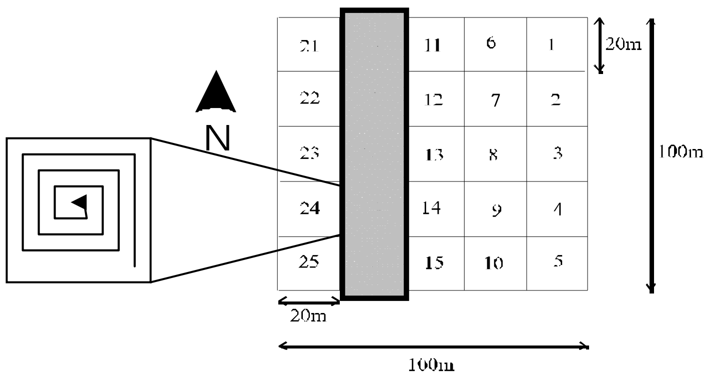
Organizational Guide for Accessing, Archiving, and Expanding the User Guide CD



Appendix D: Protocol for Shrub Sampling

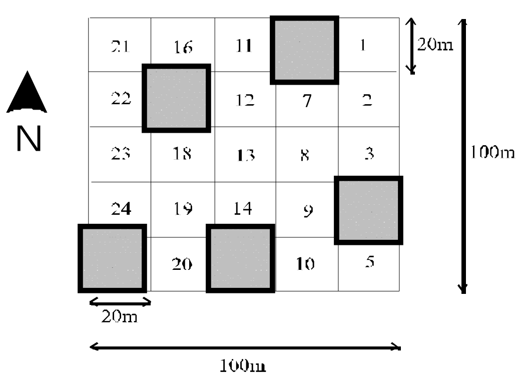
Belt Transect

A team of 2 individuals creates a 20 by 100 metre belt transect in each plot using a string to help delineate quadrat boundaries. The transect runs in a north/south direction encompassing quadrats 16 through 20. For each quadrat, the survey begins in the south-east corner of the quadrat being inventoried, and continued in concentric clockwise circles of decreasing size until the centre of the quadrat was reached. The process included locating all shrubs between 1 and 4 cm in diameter at breast height (dbh). All shrub species were identified and mapped in relation to the trees in the plot.



Knight's Move

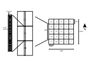
The second method is known as the "Knight's Move". Within each plot, five quadrats are inventoried according to the way the Knight moves in chess, randomly starting at quadrat four. The Knight moves in any "L" direction within the plot therefore allowing for a systematic sample of five quadrats. Again, within each sampled quadrat, all shrub species are recorded and mapped, in relation to the trees, moving in a concentric clockwise circle of decreasing size until the center of the quadrat was reached. Due to the type of Carolinian forest found in the Long Point area, it is possible to conduct this type of survey in the late summer with minimal vegetation disturbance.



Appendix E: Protocol for Sampling Ground Layer Vegetation

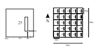
Belt Transect Subsample

A 1 by 60 metre belt transect was the first method used. The idea of a transect was taken from Stohlgren *et al.*'s (1995) "long-thin plot" design, because it reflects the total species richness of the site. A transect was oriented in a north-south direction and was established through quadrats 22, 23, and 24. All four corner posts of the transect were permanently marked with aluminum stakes. As well, a half metre buffer area was marked around the transect in order to reduce foot traffic. The transect was dissected into one-hundred and twenty 1.0 metre by 0.5 metre sub-quadrats marked with numbered steel/nylon flags. Within each sub-quadrat, subsequent ground vegetation was enumerated and each individual species was recorded onto templates.



Nested Plots

The second method used provides a systematic sample of the vegetation in the plots. Within each of the 25 quadrats, a 2.0 metre by 0.5 metre sample was documented. This sample was taken four metres west and four metres south of the northeast corner post in the quadrat. Within each sampling rectangle, all ground vegetation was enumerated and each individual species recorded on a template.



Appendix F: Formula Equations used for Statistical Analyses

$$\textbf{Frequency} = \frac{\text{Number of quadrats in which a species occurs}}{\text{Total number of quadrats in sample}}$$

$$\textbf{Relative frequency} = \frac{\text{Frequency of a species}}{\text{Total frequency of all species in the sample}} \times 100$$

$$\textbf{Density} = \frac{\text{Number of individuals in the sample}}{\text{Total area of the sample}}$$

$$\textbf{Relative density} = \frac{\text{Number of individuals of a species in the sample}}{\text{Total number of individuals of all species in the sample}} \times 100$$

$$\textbf{Dominance} = \frac{\text{Area occupied by a species in the sample } (m^2)}{\text{Total area of the sample } (m^2)}$$

$$\textbf{Relative dominance} = \frac{\text{Area occupied by a species in the sample } (m^2)}{\text{Area occupied by all species in the sample } (m^2)} \times 100$$

Importance Value Index (IVI) = relative frequency + relative density + relative dominance

$$\textbf{Brillouin Diversity Measure} = \frac{\ln(N!) - \text{sum } \ln(n!)}{N}$$

where n=abundance of species; N=abundance of all species in assemblage

Brillouin-based Evenness Measure

See Zar, J.H. 1984. Biostatistical analysis. Prentice Hall, Englewood Cliffs, N.J.

Appendix G: Methods for Calculating Tree Mortality Rates

Tree mortality rate can be calculated as numbers of stems dying annually or as cross-sectional basal area lost per year. Cross-sectional basal area is a useful surrogate for measuring the biomass that accumulates as forests age. The periodic annual increment is the rate at which biomass accumulates over short periods (e.g. decades) out to a quasi-steady state of maturity. Total forest growth has been shown to be fairly constant in forests over long periods, however, periodic annual increment decreases with age. Although probability of death is constant and the number of trees dying annually declines, the trees in older age classes that do die are relatively large and their effect on total biomass is noticeable. The amount of biomass loss due to mortality increases up until biomass accumulation begins to level off when loss of biomass to annual mortality nears the total annual biomass increment. This means that mortality rate (%) can be expressed as the annual mortality increment of standing biomass over total standing biomass, a rate that should be relatively stable in old-growth forests.

Basal Area Mortality Rate
Calculate total basal area (m^2) of live stems/area (ha) for each sample year.

Calculate periodic growth (basal area [ba]) increment (pgi) for the periods between samples *Eg: 2000-2003yr growth increment = 2003 ba – 2000 ba/3yrs*

Calculate periodic mortality increment for the same periods between samples
Eg: 2000-2003 pgi = 2000 alive ba of trees found dead in 2003/3yrs

Calculate Total periodic growth rate for the same periods
Eg: 2000-2003 total periodic growth rate = pgi + periodic mortality increment (pmi)

Calculate basal area mortality rate (%) for each period
Eg: 2000-2003 ba mortality rate = 2000-2003 pmi / mean total ba of 2000 and 2003

* Output is simplified if the period used for calculation is per annum. The distribution of basal area mortality rates can be calculated by species or dbh size classes.

Stem Mortality Rate
Tally all live stems for each sample period. Enumerate stems dying between sample periods. Subtract this number from the total stems alive at the beginning of the period. Comparing the outcome with the total stems alive at the end of the period will tell you how many new recruits occurred over the period. Subtracting new recruits from stems that have died over the period, or vice versa if there are more recruits than deaths, will give you the total number of stems that have died or been recruited in the intervening time between sampling. Dividing this stem number by the number of years of the period you will have a rate (per year) of stem deaths or recruitment. Dividing change in stems, whether deaths or new recruits, by the mean of total alive stems at the start and end of the sample period will give you a rate of mortality or recruitment respectively.

Appendix H: Trees selected for Lichen Monitoring

Trees selected for the Ladder Method			
Backus Woods	**Wilson Tract**	**Turkey Point**	**Spooky Hollow**
01-01-08 01-01-14 01-01-15 01-01-32b	02-01-03 02-01-11 02-01-40 02-01-49	04-01-15 04-01-18 04-01-38 04-01-47a	05-01-06 05-01-09 05-01-15 05-01-23
01-05-03 01-05-10 01-05-15 01-05-23	02-05-07 02-05-25 02-05-27 02-05-42	04-05-02 04-05-14b 04-05-20 04-05-32a	05-07-06 05-07-14 05-07-19 05-07-24
01-21-04 01-21-10 01-21-17 01-21-30	02-21-10 02-21-11 02-21-20 02-21-31	04-21-04a 04-21-07a 04-21-18 04-21-21c	05-10-07a 05-10-12b 05-10-23 05-10-46a
01-25-03 01-25-06 01-25-20 01-25-40	02-25-04 02-25-08 02-25-13 02-25-37a	04-25-03 04-25-17 04-25-19a 04-25-37	05-11-12b 05-11-17 05-11-18 05-11-23
Trees selected for the Photometric Method			
One stand alone tree along the trail at Normandale Fish Hatchery (43º 12.483' N, 81º 51.088' W) was selected for monitoring.		04-01-40 04-04-03b 04-21-07a 04-25-37	05-01-06 05-07-24 05-10-46a

Appendix I: Coordinates for Benthic Invertebrate Reference Sample Sites

Water body name	Lat. (N-deg, min)	Long. (W-deg, min)	Directions
Youngs Ck. (Y1)	42º 45' 43.6"	80º 16' 41.8"	50 m N from where Hwy24 crosses creek
Fishers Ck. (F1)	42º 43' 20.6"	80º 17' 55.6"	70 m N from where Front Road intersects the creek
Normandale Ck. (N1)	42º 42' 39.6"	80º 19' 09.1"	10 m N from where Front Road intersects the creek
Beckers Ck. (B1)	42º 38' 02.3"	80º 32' 39.1"	15 m N from the access trail off the Rowanwood Sanctuary Road
Trout Ck. (T1)	42º 46' 44.3"	80º 28' 32.5"	3 m upstream from where Massecar Lane intersects creek

Appendix J: Key to the Abbreviations Used in the Text

Abbreviation	Full Name
BIOMON	Biomonitoring Software Program (produced by SI/MAB)
CWS	Canadian Wildlife Service
DBH	Diameter at Breast Height
EMAN	Ecological Monitoring and Assessment Network
HNC	Hamilton Naturalists' Club
IVI	Importance Value Index
LDV	Lichen Diversity Value
LPRCA	Long Point Region Conservation Authority
LPWBR	Long Point World Biosphere Reserve
LPWBRF	Long Point World Biosphere Reserve Foundation
MOE	Ministry of the Environment
MSF	Mean Sum of Frequencies
OBBN	Ontario Benthos Biomonitoring Network
OMNR	Ontario Ministry of Natural Resources
SF	Sum of Frequencies
SI/MAB	Smithsonian Institution Monitoring and Assessment of Biodiversity Program