MONITORING ECOSYSTEM CHANGE IN CAROLINIAN FORESTS AND OAK SAVANNAHS OF SOUTHWESTERN ONTARIO

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ABSTRACT

Concerns over forest health and decline in North America continue. Pollutant-induced general forest decline has now been documented in at least 25 states across the eastern U.S. (Loucks, 1998). Although some such assessments have been done for Canada's forests, the accumulation and analysis of basic forest data is ripe with opportunity for synthesis. 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.

Forest data was compiled from Biosphere Reserve monitoring plots, Ontario Ministry of Natural Resource growth and yield plots, and the Canadian Forest Service Acid Rain National Early Warning System and analyzed to establish tree mortality rates across a variety of forest types. Our compilation and analysis of Canadian forest data provides additional support for the hypothesis that forests naturally exhibit quasi-equilibrium tree mortality. Divergent mortality rates exhibited by some of the forests analyzed can be linked to issues of sampling scale and/or damage by acid rain and air pollutants via established mechanisms. Interpreting our results using a multi-factorial model of forest health suggests that the effects of historical anthropogenic stressors, including acid rain and air pollution that garnered such high levels of attention during the 80s and 90s, may still be felt in many forests via increased stress and susceptibility to disease. Our results corroborate the existing evidence for forest decline but also link current decline to past impoverishment.

INTRODUCTION

This paper describes the Long Point World Biosphere Reserve (LPWBR) Monitoring Program and reports on forest biodiversity and ecosystem change within the Southwestern Ontario Carolinian forest ecosystems of Backus Woods, Wilson Tract and Spooky Hollow, and the oak savannahs of Turkey Point Provincial Park.

In 1995 with an aim to track and make sense of environmental change the LPWBR initiated a forest biodiversity monitoring program. The LPWBR regional monitoring program spans the Biosphere Reserve, which encompasses a large portion of Norfolk County in Southwestern Ontario. This regional monitoring is part of the larger Ecological Monitoring and Assessment Network (EMAN) comprised of local partners who work collaboratively with EMAN to implement standardized protocols for long-term ecological monitoring across Canada.

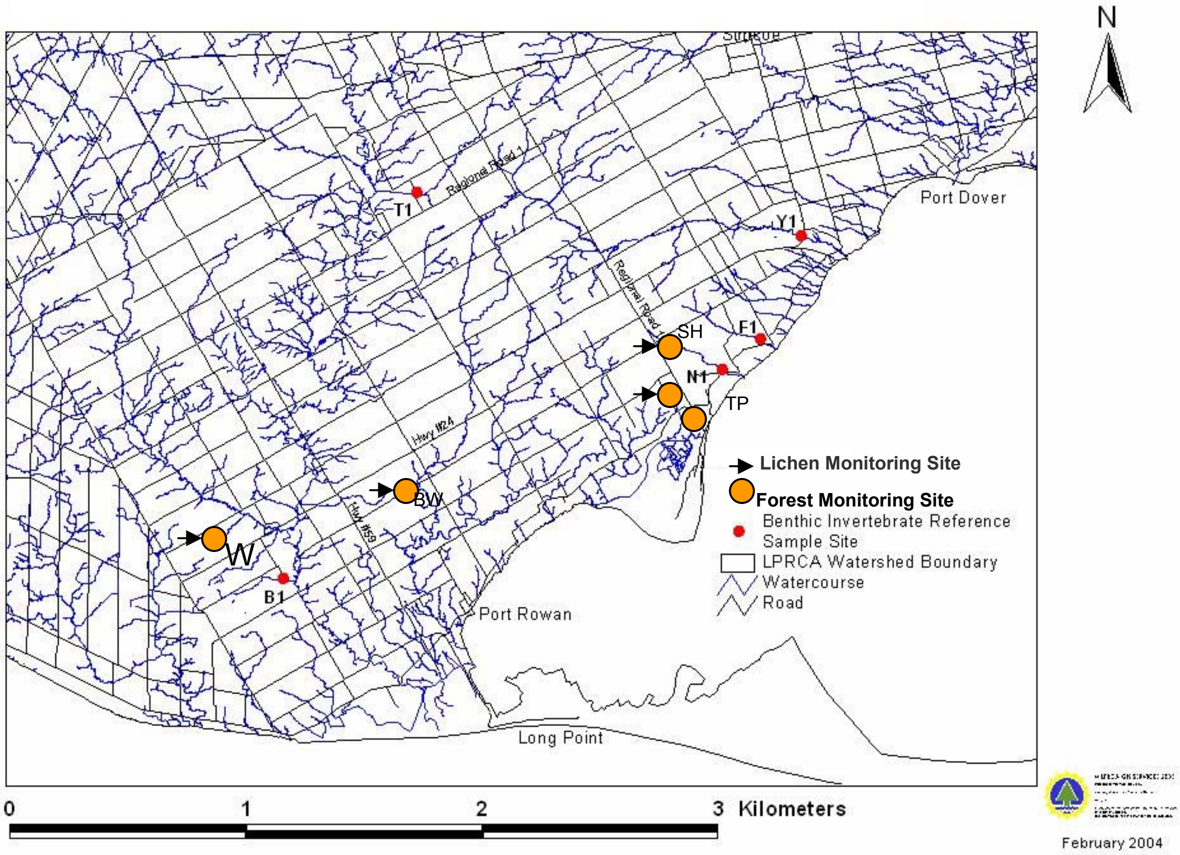
The LPWBR Monitoring Program has developed and expanded greatly since its inception. To date, the monitoring program has focused predominantly on the establishment and re-inventory of trees in the permanent forest biodiversity monitoring plots. More recently in 2003 the monitoring program was expanded to include new monitoring sites and protocols, which employ lichens, and benthic invertebrates as environmental indicators (Figure 1).

FOREST TREE MONITORING

Forest tree monitoring has been ongoing in the monitoring plots since 1995. For the purposes of comparison permanent forest biodiversity monitoring plots have been established in old-growth (Backus Woods) and late successional Carolinian forest (Wilson Tract), the latter with a history of timber and fuel wood extraction; and oak parkland with and without prescribed burns (Turkey Point Provincial Park Plots 1 and 2). Backus Woods was re-inventoried in 2000. During the summer of 2003 all four sites were re-inventoried and a new dispersed plot was set up in Spooky Hollow.

The monitoring follows the protocol outlined by Roberts-Pichette and Gillespie (1999). Field measurements include species identification, health status, diameter-at-breast-height, and mapping location. The inventory results from 1995-2003 were summarized using Biomon® and then analysed to detail ecosystem change. The forest monitoring of the past eight years suggests that overall the LPWBR forests are healthy. What follows is a brief summary of the salient findings; a detailed description of the monitoring results can be found in Parker (2003).

Figure 1: LPWBR Monitoring Sites



In Backus Woods *Acer rubrum, Pinus strobus, Quercus rubra* and *Quercus alba* are dominant in the canopy layer. However the conspicuous absence of the latter three species from the shrub layer suggests that, in the coming years, white pine and oak will play a less dominant role in the future canopy, which may decrease in diversity.

The tree layer in Wilson Tract is composed primarily of *Acer* and *Quercus* sp. The most important species in the plot are *Q. alba, A. rubrum, Hamamelis viriginiana, Fraxinus americana* and *P. strobus*. Of these the later three have undergone a decrease in stems leading to an overall stem reduction from 1995-2003.

At Turkey Point plot 1, which was subject to prescribed burns in 1994 and 1999 (Postma, pers. comm.) the tree layer is composed mainly of *Quercus velutina* and has low species richness (only five species). Other species in the plot include: *Q. alba, P. strobus, P. serotina,*and *Q. rubra.* The Turkey Point plot 2, canopy is intermittent to partially closed with very little understory and is dominated by *Q. velutina*. Over the past seven years *Q. velutina* has decreased in importance while both *P.strobus* and *P. serotina* have increased, suggesting potentially significant successional changes in the future.

The inventory of Spooky Hollow is the first to quantitatively assess forest structure in the nature sanctuary. The forest canopy is semi-mature, intermittent to partially closed and is composed of a wide diversity of species associated with early (e.g. *P. serotina*) and late (various *Acer* sp.) successional stages. Although the total area sampled was less than that of the one hectare plots 24 tree species were recorded. The high tree diversity is in part due to the dispersed sampling method employed, which encompasses a large variety of forest types and topographical features. *Castenea dentata*, a nationally and provincially rare species, occurs in Spooky Hollow, however none were recorded in the quadrats.

Basal Area Index Mortality

Pollutant-induced forest decline has been documented in the eastern U.S. and Canada (Loucks, 1998). Tree basal area index (BAI) mortality rates (basal area lost/hectare/year) were used to determine successional turnover and assess whether regional forests were experiencing significant decline (Parker *et al*., 2003).

Although total live stems continue to decline in Backus Woods the total basal area occupied by all live stems has increased over the past eight-years from 33.64 m^2ha^{-1} to 36.11 m^2ha^{-1}. Over the eight-year period of monitoring, basal area accumulation has tapered off considerably (over an order of magnitude), while basal area mortality has increased slightly which suggest that the forest is reaching internal biomass quasi-equilibrium (Table 1). The mortality rates observed over 1995-2003 are within the natural range expected (0.4 - 0.8 %) for old growth deciduous forests (Loucks, 1995). The observed increase in recruitment is likely a concomitant response to increased resource availability due to the slightly higher rate of mortality.

Table 1: Changes in Basal Area Accumulation and Mortality Rate in Backus Woods from 1995-2003

Time Period	Annual Basal Area Accumulation (m^2ha^{-1})	Annual BAI Mortality Rate (m^2ha^{-1})
1995-2000	1.33 %	0.38 %
2000-2003	0.14 %	0.65 %
1995-2003	0.89 %	0.49 %

BAI mortality in Wilson Tract is lower (0.14%) than in Backus likely because it is not yet mature and there has been historic harvest from this site, which would result in lowered basal area overall as well as increased regenerative growth. Mortality rate is likely to continue to increase as succession proceeds.

The important ecological role of fire in maintaining Oak parkland is evident in the difference between the mortality rates of the two Turkey Point plots. In the undisturbed parkland of Turkey Point 2 the BAI mortality rate was 0.99%. Over a hundred year period 99% of the trees in this Oak parkland ecosystem will be replaced. Such high turnover rates are typical of ecosystems reliant on periodic disturbance. Turkey Point 1, which underwent the prescribed burns, has had a 7.27 % mortality rate from 1996-2003. The halted succession has produced a canopy that is patchy, primarily composed of *Q. velutina* and *P. strobus*. As a result, colonising species like *P. serotina* and young, shade-intolerant trees, like *Q. velutina* and *Q. alba* have begun to appear in 2003. The influence of the prescribed burn is evident via high stem mortality, a large proportion of dead fallen stems present, lack of stem recruitment, loss of over 50% of tree biomass over 7yrs, and changes in species composition.

Of concern is the Eastern flowering dogwood *(Cornus florida)* dieback first noted in 2000, which has continued to increase over the last eight years. To date 72% of the dogwoods in Backus Woods have died. A similar pandemic has occurred in Wilson Tract. This is primarily the result of *Discula destructiva*, a fungus that kills dogwoods of all sizes but is particularly severe on seedling and understory trees. If left unchecked, *D. destructiva* has the potential to destroy the significant dogwood populations found in the LPWBR in the next five to ten years. (Canadian Forest Service, 2001).

Lichen Community Diversity

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). By tracking the composition of lichen communities over time (i.e. the distribution and abundance of lichen species) one can assess past and ambient air quality.

In total sixteen quadrats at four separate sites were sampled for lichen abundance and diversity. Turkey Point #1 was not inventoried because of its limited lichen community, a result of a prescribed burn in 1993. Monitoring of lichens followed the protocol in development by EMAN based on Asta et al. (2002). Lichen diversity values (LDV) were calculated for each site (Table 1). A LDV change greater than the Class Width (equal to three standard errors of the LDV) will be taken to mean that the lichen community has undergone a significant change and follow-up research will be initiated.

Table 1: Lichen Diversity Values and Class Widths (2003)

Monitoring Site	**2003 LDV** (number of lichens)	**2003 LDV Class Width** (number of lichens)
Backus Woods	17.3	2.2
Wilson Tract	13.9	2.0
Turkey Point #2	19.1	2.5
Spooky Hollow	19.8	2.5

The arboreal lichen monitoring in the LPWBR revealed a diverse community comprised of a variety of common and widespread lichens that are typical of the mixed hardwood forests of southern Ontario. The lichen species found include those that are tolerant of slight-moderate levels of air pollution such as *Candelaria concolor, Candelariella efflorescens, Flavoparmelia caperata,* and *Graphis scripta*. Lichen species that are intolerant of pollution, namely *Usnea sp.* and *Lobaria sp*., were not found in the monitoring sites, nor have they been documented in the surrounding regional forests of Norfolk County since 1940 (Wong, pers. comm.). Their absence may speak to historic loss of habitat and the air quality of the region as a whole. In future analyses, overlaying maps of meteorology and regional pollutant concentrations may provide insight into changes in LDVs.

BENTHIC INVERTEBRATE COMMUNITY ABUNDANCE AND DIVERSITY

Benthic invertebrates are good indicators of water quality because they are relatively long-lived, sensitive to changes in water and sediment quality, ubiquitous, and good integrators of environmental impacts (OBBN, 2003). Benthic monitoring is being carried out co-operatively with the Long Point Region Conservation Authority and the Ontario Benthic Biomonitoring Network.

The reference condition approach (RCA) followed relies on sampling the benthic invertebrate communities of least impacted streams in order to establish a normal range of variability for comparison with the more impacted test sites. The five reference sites selected for sampling represent a range of physiographic environments, which will enable comparison with test sites across the region (Figure 1). Taxa that are sensitive to water quality (mayflies, stoneflies, and caddisflies) were present at all sites, indicating relatively high water quality. Once sites are sampled multiple times at different periods in the year and combined with other physically similar sites from the OBBN database we will have a more comprehensive understanding of the spatial and temporal variability associated with such benthic communities.

FUTURE PROSPECT FOR THE LPWBR ECOSYSTEMS

Although the forests of the Long Point region are subject to a wide array of stressors including fragmentation, historic timber and fuelwood extraction, high loadings of ground-level ozone and exceedences of acid deposition targets, overall, they continue to exhibit a high degree of resilience. Forests are progressing along expected successional trajectories, while tree mortality rates indicate healthy turnover, which will maintain old-growth forests. However, the unprecedented decline of *C. florida,* which continues across all regional forests begs the question of what action to take? In light of this far-reaching species decline collecting seed from remaining individuals for *ex situ* propagation and subsequent reintroduction would be prudent.

Although useful in and of itself, the importance of the preliminary inventory of lichens and benthic invertebrates will be realized as monitoring proceeds. Over the long-term our monitoring indicators will act as an integrated monitoring suite that will track changes across the LPWBR's terrestrial, atmospheric, and aquatic environments. Through our efforts to track and understand change in these ecosystems we will be able to provide feedback and direction for conservation and development within the LPWBR.

RESOURCES

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