RESTORING DISTURBED CAROLINIAN PLANT COMMUNITIES

PART 1: THE PLANT COMMUNITY COMPOSITION OF OAK SAVANNA REMNANTS IN SOUTHERN ONTARIO (PINERY PROVINCIAL PARK, POINT PELEE NATIONAL PARK AND RONDEAU PROVINCIAL PARK)

PART 2: RECOVERY OF RESTORED COTTAGE SITES IN POINT PELEE NATIONAL PARK

PART 3: EXPERIMENTAL REINTRODUCTION OF VULNERABLE NATIVE HERBACEOUS AND WOODY SPECIES TO A MODEL SOUTHERN ONTARIO CAROLINIAN FOREST

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EXECUTIVE SUMMARY

- ❖ Southwestern Ontario is the most densely populated, urbanized, industrialized and intensively farmed part of Canada. The remaining natural habitat cover is 5-10%, and much of this has been subjected to intense human-induced disturbance in the past. Conservation and habitat restoration is, to put it mildly, a huge challenge.
- ❖ This report explains the 2000 fieldwork results of 3 projects funded by the ESRF, which comprise the research of 2 York University graduate students, Cecilia Tagliavia and Kim Hynes.
- ❖ The overall aim of the research was to determine how best to restore Carolinian plant communities, specifically Oak Savanna and closed canopy Carolinian forest.
- ❖ Oak savanna is to some degree a fire-dependent plant community. Rare and endangered species (e.g. Wild Lupine and Karner Blue Butterfly) are present and the community itself is considered to be extremely rare in Ontario and globally imperiled.

❖ For Oak Savanna communities our goals were:

1.0 To characterize the plant community composition of treed Oak Savanna remnants in Pinery Provincial Park, Point Pelée National Park and Rondeau Provincial Park.

2.0 To assess the effects of restoration efforts (prescribed burns, deer herd reductions and deer exclusion) on plant community composition.

- ❖ The Oak Savanna plant communities in the 3 parks have similarities, but it is clear that some sites are very different - especially the degraded Oak Savanna sites at Point Pelée, where succession has clearly proceeded to the point where there is a more-or-less closed canopy forest community. There are similar sites at Rondeau where, before prescribed burns are carried out, considerable clearing efforts may be required. However, we conclude that overall, prescribed burns at all sites will result in increases in the presence of savanna and prairie species.
- ❖ In the future, the recovery rates of these Oak Savanna communities will depend on the presence of a suitable seedbank (currently under investigation) and the dispersal rates of individual plant species from local seed sources.
- ❖ Intensive deer herd reductions, removal of planted pines, and prescribed burns at Pinery Provincial Park are allowing the Oak Savanna plant communities to move away from the species composition of the early to mid-1990s, towards communities characterized by prairie and savanna species. We support the proposals to continue deer herd reductions and prescribed burns at Pinery for the foreseeable future.

❖ For closed canopy Carolinian forests, our goals were:

1.0 To follow the further recovery of 4 restored cottage sites of various ages at Point Pelee National Park to determine whether light levels have decreased and native species have increased.

2.0 To determine whether the establishment and growth of some native woodland species is limited more by dispersal than by light conditions and competition from non-native species. An experiment introducing native tree species and herbs to the Sturgeon Creek site was carried out to determine how they would survive and grow in a young, early successional forest.

- In previously restored cottage sites, there were no significant changes in species composition over 4 years although the sites had changed, and in 1 site, there were fewer non-native species. Clearly, at Point Pelée, the drier, more open sites are not likely to succeed to closed canopy forest and park managers may consider managing these sites as treed savanna communities.
- In Sturgeon Creek, where a young, early successional forest has been established since 1993/94, native tree and herb species, including red mulberry (*Morus rubra*), blue ash (*Fraxinus quadrangulata*), and hoptree (*Ptelea trifoliata*) were all able to survive and grow, with varying degrees of success, in various locations, suggesting that for many of these species, barriers to seed dispersal will be the main factor preventing their colonization of restored forest habitats.
- Overall, the 2000 field season has demonstrated that active management efforts in Carolinian plant communities have the potential of successfully restoring and rehabilitating highly disturbed habitats.

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- Overall, the 2000 field season has demonstrated that active management efforts in Carolinian plant communities have the potential of successfully restoring and rehabilitating highly disturbed habitats.

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General Introduction

Southwestern Ontario is the most densely populated, urbanized, industrialized and intensively farmed part of Canada. The remaining natural habitat cover is 5-10%, and much of this has been subjected to intense human-induced disturbance in the past (see McLachlan 1997 for a review of the disturbance history in this region). Additionally, this part of Canada, which is in the Carolinian Ecozone, contains a high proportion of both provincial and federal rare, endangered and vulnerable species. Conservation and habitat restoration is, to put it mildly, a huge challenge. This report explains the 2000 fieldwork results of three projects funded by the ESRF, which comprise the research of 2 York University graduate students, Cecilia Tagliavia and Kim Hynes. The overall aim of the research was to determine how best to restore Carolinian plant communities, specifically Oak Savanna and closed canopy Carolinian forest. In the Oak Savanna plant communities that have been overgrazed by white-tailed deer, the ultimate goal is to reintroduce the extirpated Karner Blue Butterfly. In the case of closed canopy forest, in the Leamington region, the goal of habitat restoration in Point Pelée National Park has been to rehabilitate former in-park cottage and road sites to forest, and to also find ways to link the park with external, regional natural habitat. This report is divided into three sections, dealing with each of these goals.

PART ONE: THE PLANT COMMUNITY COMPOSITION OF OAK SAVANNA REMNANTS IN SOUTHERN ONTARIO

1.1 INTRODUCTION

Oak savanna is to some degree a fire-dependent plant community (Bond & Wilgen 1996). Rare and endangered species (e.g. Wild Lupine and Karner Blue Butterfly) are present and the community itself is considered to be extremely rare in Ontario and globally imperiled (NHIC 1996). The Oak Savanna in Wisconsin and the Midwest USA is also considered extremely rare (Leach & Givnish 1998). The overstorey layer is characterized by the presence of *Quercus* spp. In southwestern Ontario we found *Q. velutina*, *Q. alba*, *Q. rubra*, *Q.velutina-rubra*, *Q.prinoides*, and *Q. muhlenbergii in* order of abundance (Tagliavia 2001). In the USA Midwestern Savanna *Q. velutina*, *Q. alba*, *Q. bicolor*, *Q. macrocarpa*, *Q. ellipsoidalis-velutina* (Bray 1960) are the dominant species. The Oak Savanna plant community is a blend of species, some of which are found in prairie and forest habitats, all part of the complex ecozone existing between the major biomes (Temple 1998). Some of the herb species found in Oak Savanna sites in both Canada and USA are *Helianthus* spp., *Carex* spp, *Pycnanthemum* spp., *Andropogon* spp. and *Galium* spp. (Bray 1960, Bakowsky 1988).

Previous studies have selected Oak Savanna sites differently. Some have given more weight to the presence of prairie species, others to that of warm–season grasses. Leach and Givnish (in press) give 3 site-selection criteria: 1) a canopy layer of open grown Oaks, 2) a ground layer dominated by native species, both in sunny and shaded areas, and 3) a history of fire in the past 10 years. We suggest that site history of fire should not be restricted to the past 10 years, but to the past in general. The first and third criteria were used for the selection of sites during this research. The second criterion may not always be met in highly disturbed sites. Three Oak Savanna remnants in southwestern Ontario were selected for this study: Pinery Provincial Park, Point Pelée National Park and Rondeau Provincial Park (Figure 1.1).

The Oak Savanna communities are considered by Ontario Ministry of Natural Resources personnel to be relatively stable, and may be a successional endpoint (A. Woodliffe, pers. comm., T. Crabe, pers. comm.). Fire, deer grazing, climatic and topographic characteristics of the region could be factors that maintain this community in a "stable" equilibrium. In the terminology of Clements (1916), this will be identified as a 'sub-climax' community or, as Godwin (1929) suggests, a 'deflected' one. The interruption or change of the proper disturbance regimes (e.g. suppression of fire and overgrazing) could affect the plant community, pushing it towards a climax community (e.g. deciduous forest), which we hypothesized may have been happening in our sites.

The goals of this study were:

1) To characterize the plant community composition of treed Oak Savanna remnants in Southwestern Ontario.
2) To assess the effects of restoration efforts (prescribed burns, deer herd reductions and deer exclusion) on plant community composition.

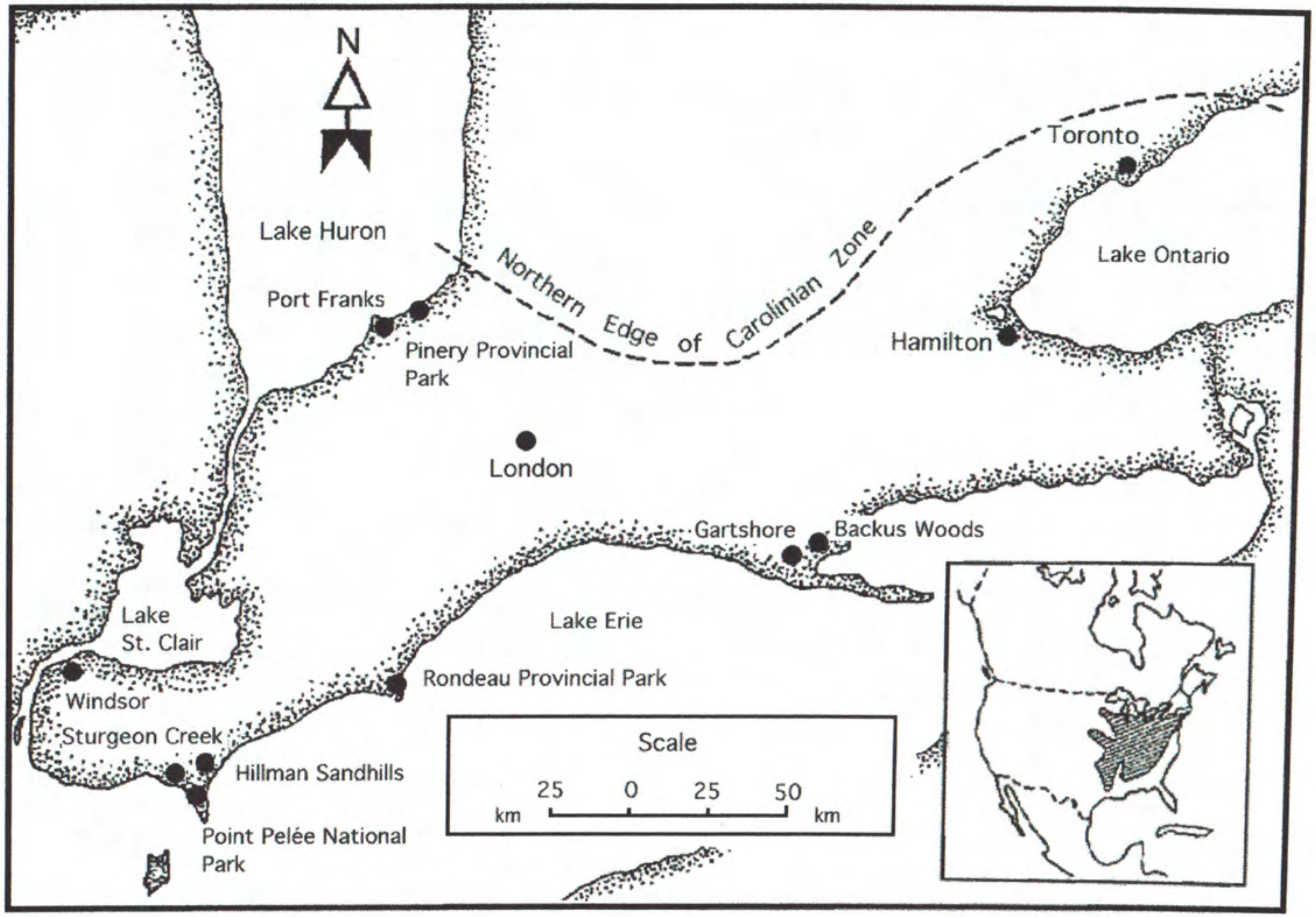

Figure 1.1: Regional locations of Oak Savanna and Carolinian forest study sites in Southwestern Ontario.

1.2 METHODS

At Pinery Provincial Park, 20 permanent deer exclosures were built in 1994 in Oak Savanna plant communities. Herd reductions were undertaken in 1998 and 1999, and some sites were burned between 1989 and 1993 (T. Crabe pers. comm., Bakowsky 1995). To test the prediction that deer overgrazing has affected the plant community composition in Pinery, plant species composition inside (ungrazed plots) and outside exclosures (grazed plots) were compared. The same plots were compared to asses the effect of deer herd reduction, which we hypothesized would promote the rehabilitation of the Oak Savanna plant communities. To test the prediction that early spring burning would promote the recovery of oak savanna vegetation, community composition was compared in burned and unburned sites at Pinery Provincial Park, where a prescribed burn was carried out in April 2000 in 4 areas of Oak Savanna. In Rondeau Provincial Park, 3 of the 5 sites have been the scene of accidental fires between February and May 2000.

In Pinery Provincial Park, we have data on Oak Savanna plant community composition in 1994, for the 20 (2m x 2m) deer exclosures built in the Oak Savanna habitat, in order to study the effect of deer grazing in the park and their adjacent grazed control plots. In 2000 we added a second control, plot external to each large exclosure. In 2000, we also built 12 new 1.2m x 1.2m chicken wire exclosures, in order to monitor the effect of deer grazing in 4 new sites where prescribed burns (PBs) were carried out in late April 2000 (Figure 1.2). These burns were low-intensity hand fires, and close to 99% of the area burned was covered in black ash in our first sample. Each exclosure had 1 or 2 associated controls plots placed at randomly selected directions approximately 3m away. Control plots were marked by a 30-40 cm long 2" x 2" wooden stake. The percentage cover and frequency of stems of understorey species (below 40 cm height above ground) was recorded in 1m x 1m quadrats both inside exclosures (ungrazed plot located in the opposite corner to the door in the large deer exclosures, and 10 cm from the fence to avoid edge effects, and in the middle of small chicken wire exclosures) and outside the exclosures (control=grazed plots). There were a total of 86 plots (n = 32 un-grazed and n = 54 grazed).

In Point Pelée National Park, a total of 10 transects were established along the west side of the park, at 5 sites. Transects were paired and located as follows: **T1:** Pioneer beach, **T2:** Sleepy Hollow, **T3:** The Dunes, **T4:** Northwest Beach, **T5:** Black willow Beach (Figure 1.3). At each site, 1 transect was placed in the sand dune area in a north-south direction (e.g. T1 SD), which was recently classified as a grass-dominated community (McLachlan 1997). The second transect was placed parallel to the first, to the east, in sites identified as a highly degraded Black Oak Savanna (e.g. T1 OS) (Gary Mouland, pers. comm.), recently classified as forest habitat (McLachlan 1997). Five permanent plots were established at intervals of 5m -10m along each transect, for a total of 50 plots in the park. All plots were marked with wooden stakes.

In Rondeau Provincial Park, 5 areas were selected that had been identified as remnants of Oak Savanna by the park staff and on an old map of the park (M. Natvik, pers. comm., Carman 1928) (Figure 1.4). One site was designated "**D**", the disturbed site, which had not been burned since the 1920s. This was located in the area between the tennis court and Bennett Road. A north-south transect was established. Ten plots were randomly selected along the transect and marked with 2" x 2" wooden stakes. In a further 3 sites, 5 plots were randomly selected and marked with wooden stakes: **O 1:** Oak Savanna 1, a site not burned according to the knowledge of park staff, located on the east side of Harrison trail; **O 2:** Oak Savanna 2, a site burned accidentally in February 2000, located on the west side of Harrison trail south of Bennett road; and **O 3:** Oak Savanna 3, a site burned accidentally in March 2000, located on the east side of Harrison trail, before reaching the Group Camping site.

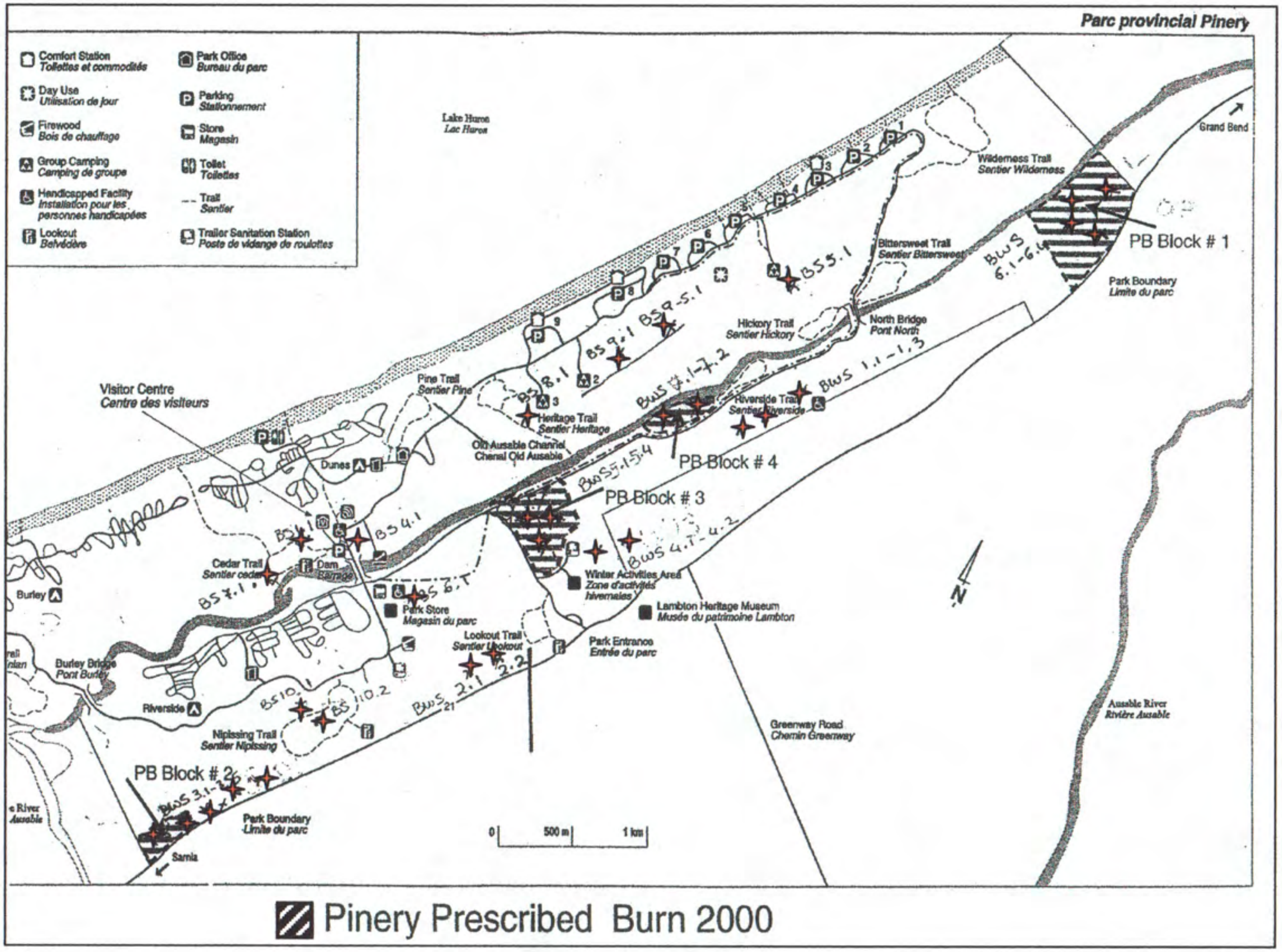

Figure 1.2: Burned Oak Savanna sites in Pinery Provincial Park.

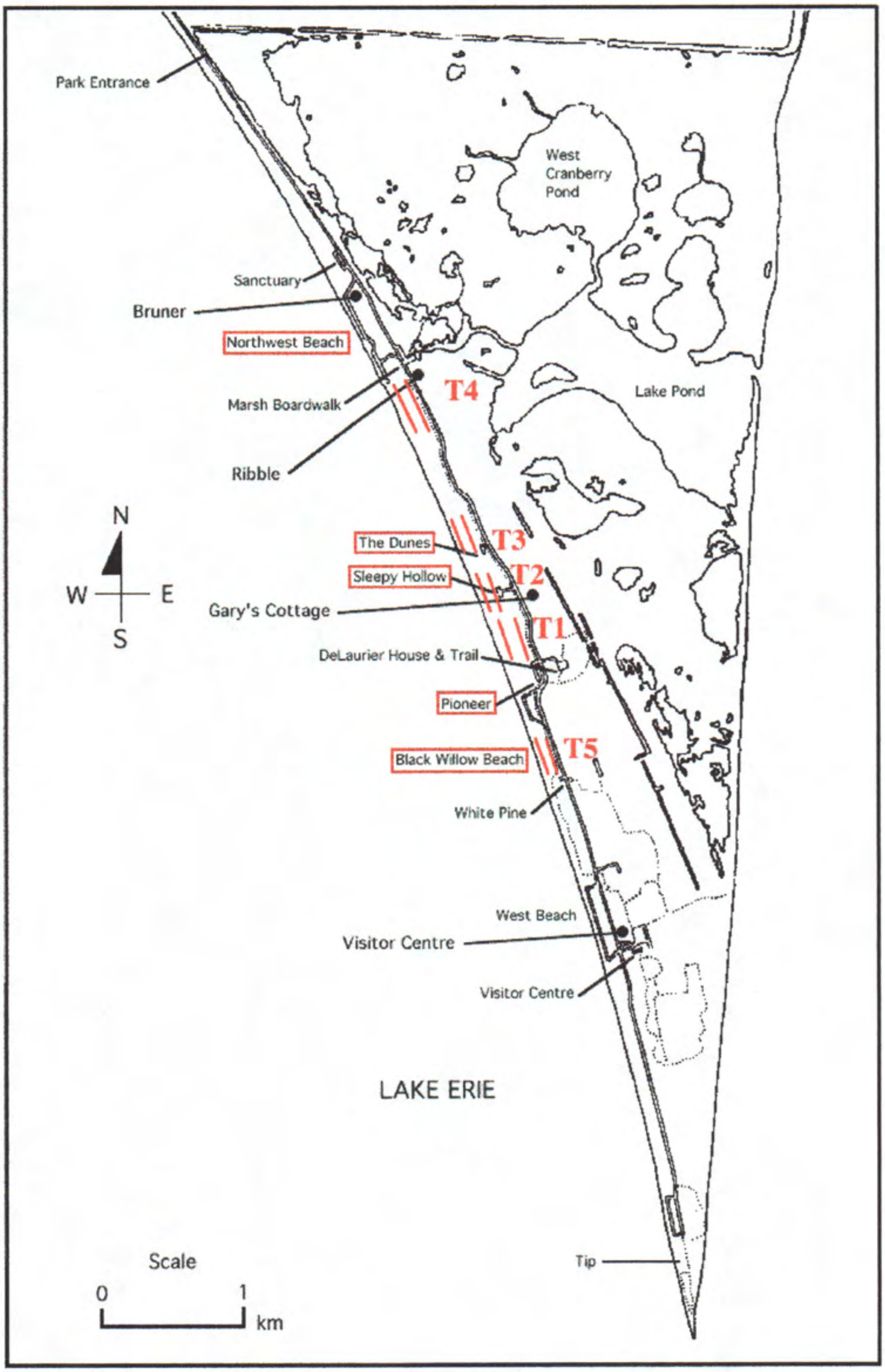

Figure 1.3: Locations of Oak Savanna sites (red boxes around park locations) (report Part One) and restored cottage sites (black circles) (Part Two) in Point Pelée National Park. Red lines and text indicate specific transects at the Oak Savanna sites.

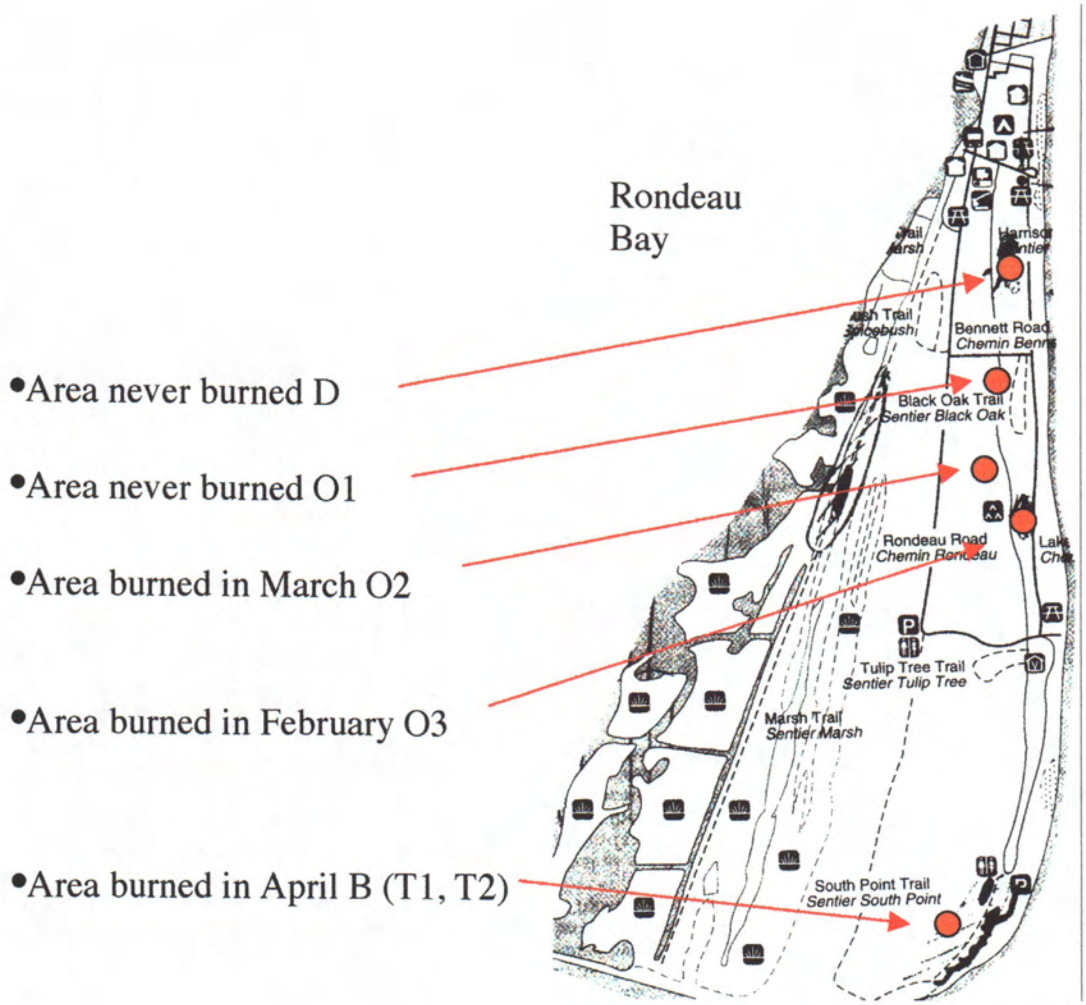

Figure 1.4: Burned and unburned Oak Savanna sites in Rondeau Provincial Park.

The final site, located on the west side of South Point Trail, was accidentally burned in May 2000. It was designated "**B**" for being a burned area and 2 parallel north-south transects were established: **T1** and **T2**. Along each transect, 4 1.2m x 1.2 m deer exclosures were built at randomly selected points. An additional transect of 6 control plots was also established along each transect for a total of 20 plots. Overall, there was a total of 45 plots established in Rondeau.

In 2000, the understorey plant community composition was sampled 3 times in all plots, in spring (May 8 -June 8), summer (July 6 - 20) and late summer (August 16 - September 7). Percent cover and frequency were assessed in 1m x 1m quadrats placed at precise locations at each plot.

1.2.1 Statistical analyses

A multivariate approach was used to analyze the plant species composition of the Oak Savanna communities. Detrended Correspondence Analysis (DCA) was performed with the maximum cover observed over the season for each species, using CANOCO version 4.0 for Windows (ter Braak & Smilauer 1998). We first looked at the composition and distribution of the plots within each park, and then we compared the 3 parks. The first and second DCA axes accounted for the most variability, and their units are standard deviations (SD). Note that SD $\geq$ 4 indicates a significant difference between plots/sites (ter Braak & Smilauer 1998). Only plot data are shown in the results. Species plots have not been included in this report, but are available and will be included in the MSc thesis of C. Tagliavia.

1.3 Results and Discussion

1.3.1 Pinery Provincial Park

The DCA (Figure 1.6) for the Pinery Provincial Park cover data shows that in 1994 all of the plots, both grazed and ungrazed, were very similar in their plant community compositions, in that they have clustered together. This homogeneity was probably due to the previous years of intense deer overgrazing. The Ontario Ministry of Natural Resources recommended carrying capacity for park deer herds of approximately 7 deer km^{-2} (D. Voigt pers. com.). The deer density in the park was estimated at 73.2 deer km^{-2} in 1993, and from 1998 to 2000 deer culls have significantly reduced these densities (1998: 69 deer km^{-2}, 1999: 27.3 deer km^{-2}, 2000: 19 deer km^{-2} (Figure 1.5).

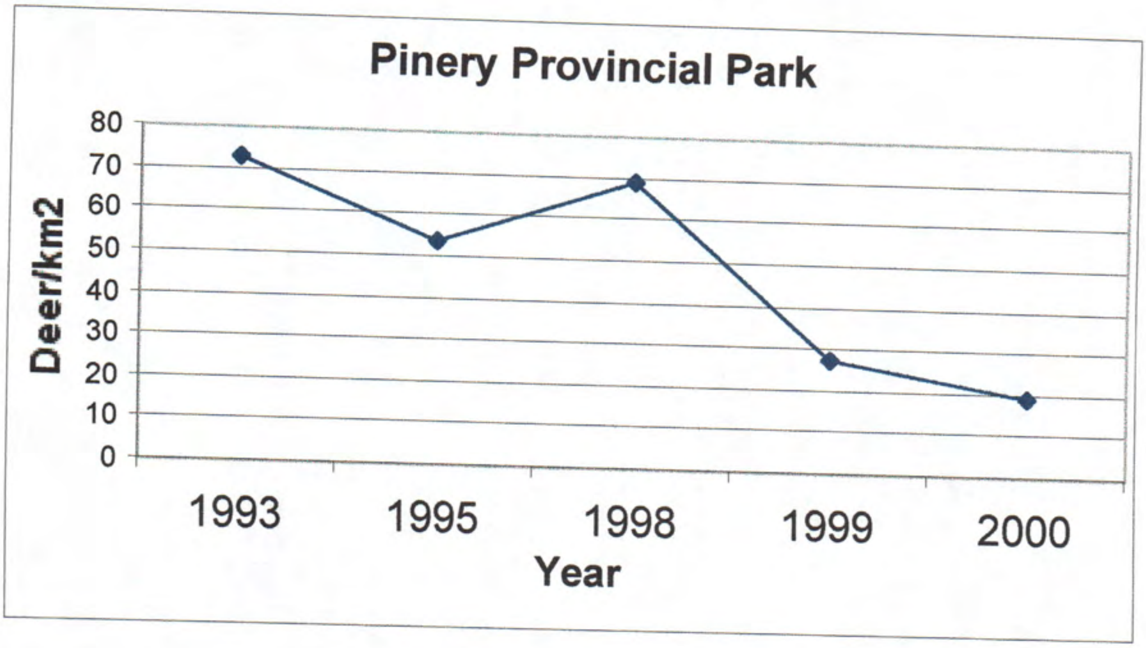

Figure 1.5: White-tailed deer densities at Pinery Provincial Park from 1993 to 2000.

Over the last 6 years, reduced grazing pressure has had a positive influence, as shown by the fact that grazed and ungrazed plots were not separated in 1999. In Figure 1.6 all plots are designated by black triangles due to the extensive overlap. We therefore concluded that the grazed plots have followed a similar recovery trajectory as the ungrazed plots. In 2000, plots in 2 of the 4 burned areas of Oak Savanna (Figure 1.2, prescribed burns) with lower canopy cover, showed increased cover of prairie species. Plots in the 2 burned sites that had greater canopy cover, did not show any particularly dramatic post-fire effect and overlapped with the 1999 plots. This may be due to lack of a seedbank due to deer overgrazing. Species found in plots are listed in Appendix 1.

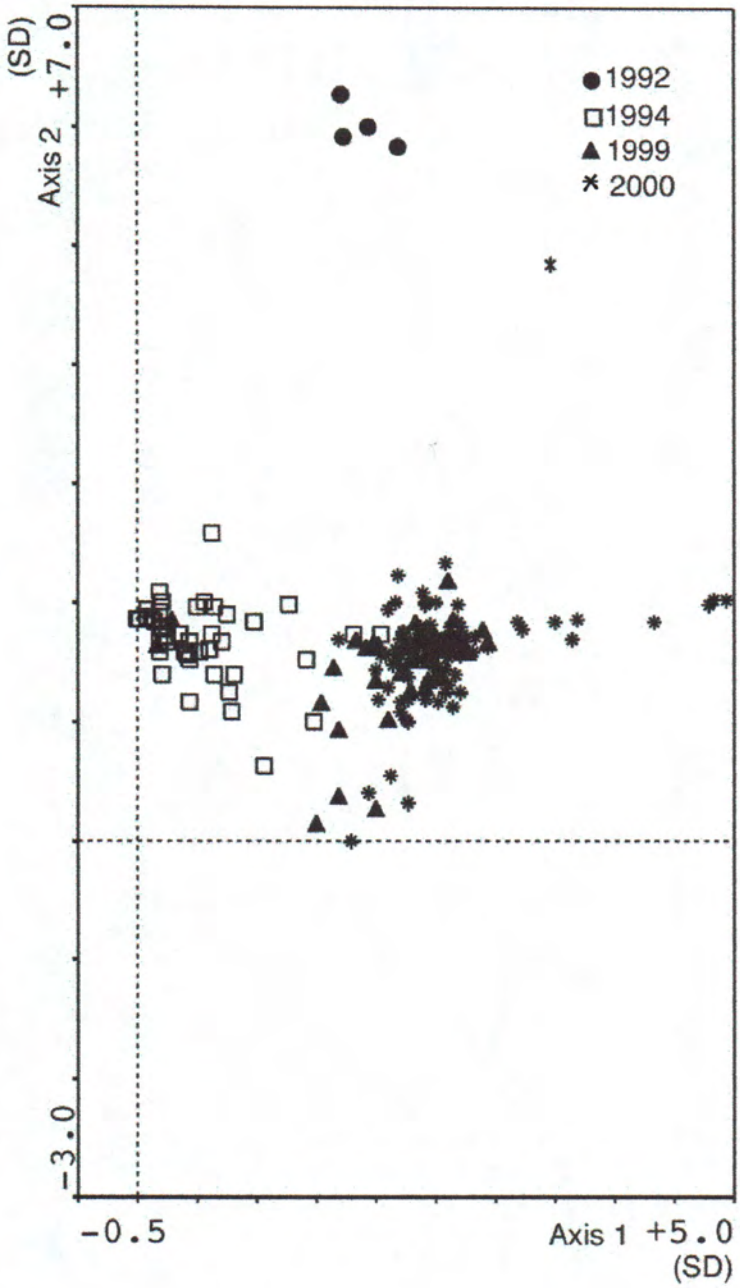

Figure 1.6: DCA (axes 1 and 2) showing plots (quadrats) at Pinery Provincial Park over different years of the study. Exclosed (ungrazed) and control (grazed) plots are not shown separately, since they overlapped within years.

1.3.2 Point Pelée National Park

In Point Pelée National Park the two plant communities sampled were very different in their species compositions and are separate in the DCA diagram (Figure 1.7). The sand dune area had species characteristic of grassland and sand dune such as *Arenaria stricta*, *A. serphyllifolia,* and *Artemisia* spp. The Oak Savanna remnants were characterized by the presence of *Smilax* spp., *Viola* spp., and *Alliaria petiolata.* Species found in plots are listed in Appendix 1.

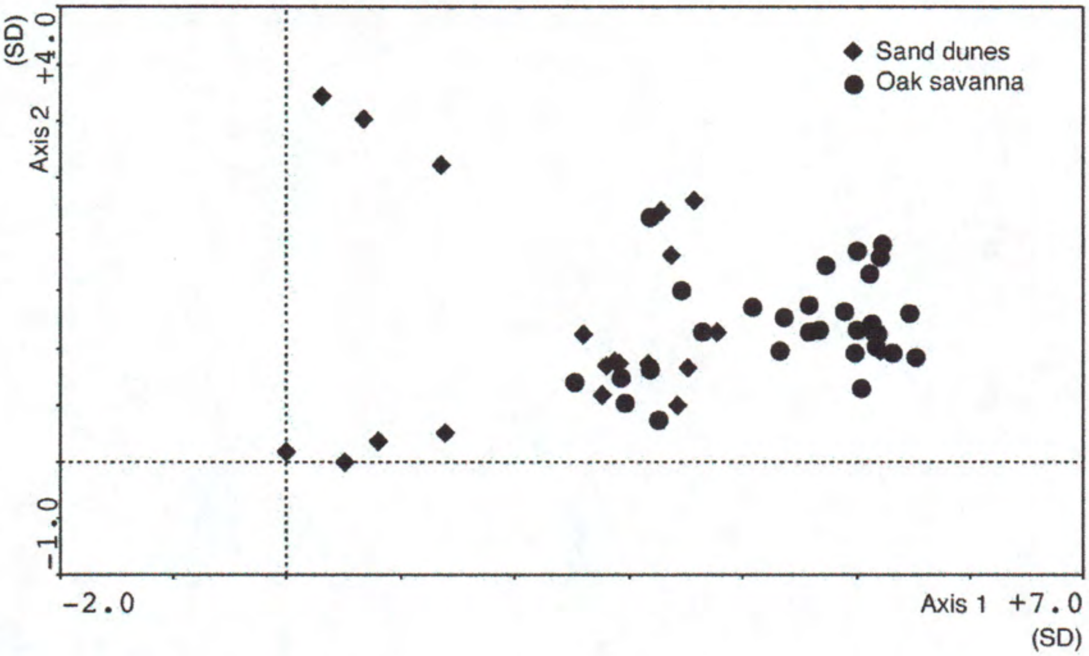

Figure 1.7: DCA (axes 1 and 2) showing Oak Savanna and Sand Dune plots (quadrats) at Point Pelée National Park in 2000.

1.3.3 Rondeau Provincial Park

In Rondeau the burned sites had a great abundance of Big Bluestem, *Andropogon gerardii*, compared with unburned sites. The DCA (Figure 1.8) shows that the burned areas had greater species diversity than the fire suppressed ones, for which plots cluster together, demonstrating greater homogeneity. Species found in plots are listed in Appendix 1.

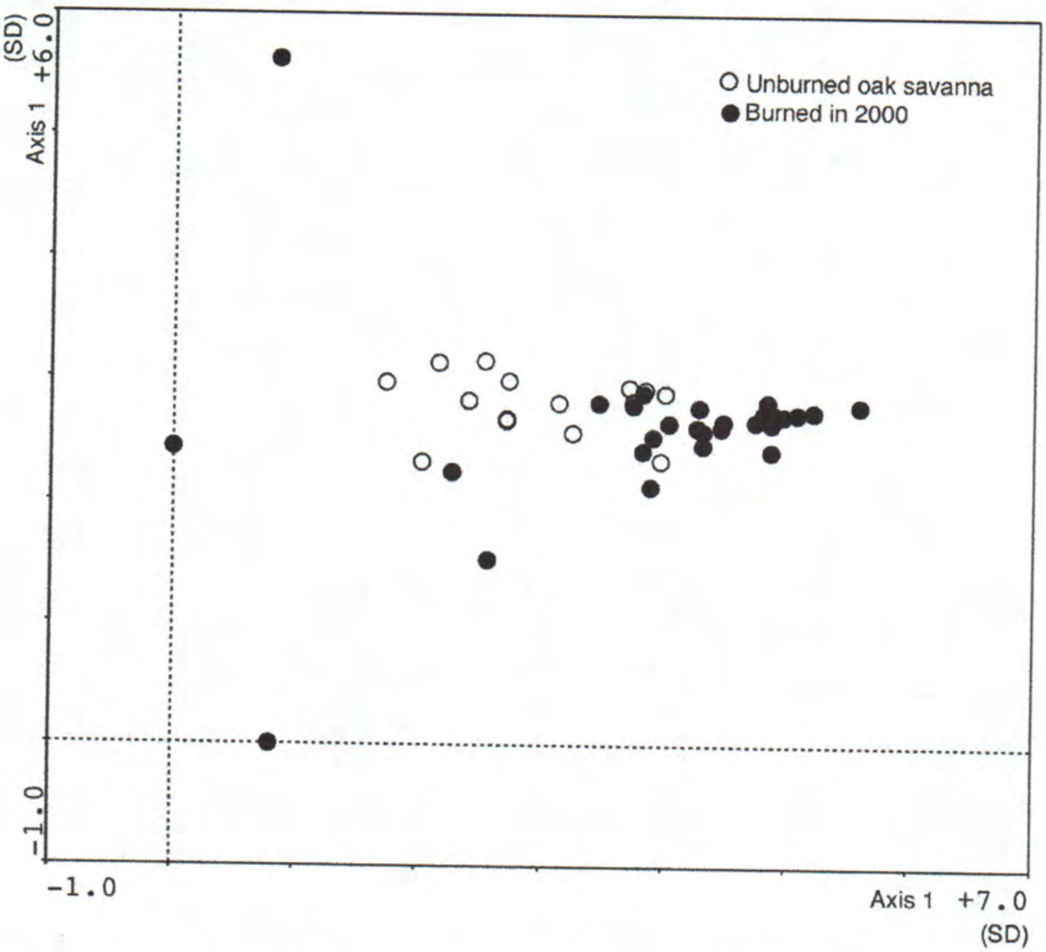

Figure 1.8: DCA (axes 1 and 2) showing plots (quadrats) at Rondeau Provincial Park in 2000.

1.3.4 Comparison between all sites

In the DCA of the combined data for 2000 (Figure 1.9) the 3 parks can be clearly distinguished, although there is clearly a great deal of overlap or commonality in some plots. One interpretation of these preliminary data is that the first DCA axis corresponds to a light gradient - once all sites have been characterized for their incoming irradiance levels, this hypothesis can be evaluated.

The Oak Savanna sites at Point Pelée were much separated from the rest of the plots. These Point Pelée sites contained a high number of Carolinian forest species. They were previously identified from aerial photographs, as forest locations in 1994-5, because of their closed canopy (McLachlan 1997). The burned plots at Rondeau occur close to the burned plots at Pinery on the DCA, and also overlap with some of the Point Pelée sand dune plots. Burned areas were generally characterized by the presence of species such as *Andropogon gerardii*, a warm season grass which is found in most of the prairie habitat (Anderson 1998). Our results tend to confirm previous findings that show how early spring fires may promote the germination of late summer grasses (Tester 1989 & 1996, Garza & Blackburn 1985). The Black Oak Savanna plots at Pinery (those in areas of the park closer to Lake Huron) were more similar in plant community composition to the Rondeau plots and the Point Pelée sand dune plots. The Black-White Oak Savanna plots park closer to Lake Huron) were more similar in plant community composition to the Rondeau plots and the Point Pelée sand dune plots. The Black-White Oak Savanna plots at Pinery (those further from Lake Huron) are found in the bottom left corner of the DCA diagram, far from the Oak Savanna Point Pelée plots, which are at the upper left corner of the diagram. These Pinery plots were characterized by the presence of *Vaccinium angustifolium* and *Pteridinium aquilinum*, which do not occur in Rondeau and Point Pelée.

Other distinguishing features of the park plant communities include the following: in Point Pelée there were more forest species and the unique presence of the exotic species, garlic mustard, *Alliaria petiolata*. In Rondeau there were many "classic" prairie species, and Lindsay Rodger, who authored the Tall Grass Prairie Recovery Plan for Ontario (Rodger 1998) has commented, in 2001, on how strange it is to see tiny patches of prairie vegetation surrounded by closed canopy Carolinian forest. Her comment highlights the fact that the plant communities at all three parks are extremely patchy and heterogeneous, due to the physiographic nature of the sand dunes and slough and ridge systems that form these parks. Some of the Pinery sites were dominated by the fern *Pteridium aquilinum*. Clearly, there were some regional differences.

1.4 Conclusions and Recommendations

Intensive deer herd reductions, removal of planted pine trees and prescribed burns at Pinery Provincial Park are allowing the Oak Savanna plant communities to move away from the species composition of the early to mid-1990s, towards communities characterized by prairie and savanna species. We support the proposals to continue deer herd reductions and prescribed burns at Pinery for the foreseeable future.

The Oak Savanna plant communities in the three parks have similarities, but it is clear that some sites are very different - especially the degraded Oak Savanna sites at Point Pelée, where succession has clearly proceeded to the point where there is a more-or-less closed canopy forest community. There are other sites at Point Pelée, namely red cedar savanna communities, which have understorey plant communities with greater similarities to the Oak Savanna communities in the other two parks (Falkenberg 2000, Tagliavia *et al* 2000). Management (prescribed burn) efforts may be more effective in these sites. Similarly, it is likely that prescribed burns at Rondeau in all sites except D, which would require considerable clearing efforts, will benefit the savanna and prairie species. However, both the D site at Rondeau and the Oak Savanna sites at Point Pelée, do have some remaining characteristic Oak Savanna species. In the future, the recovery rates of these Oak Savanna communities will depend on the presence of a suitable seedbank (currently under investigation) and the dispersal rates of individual plant species from local seed sources.

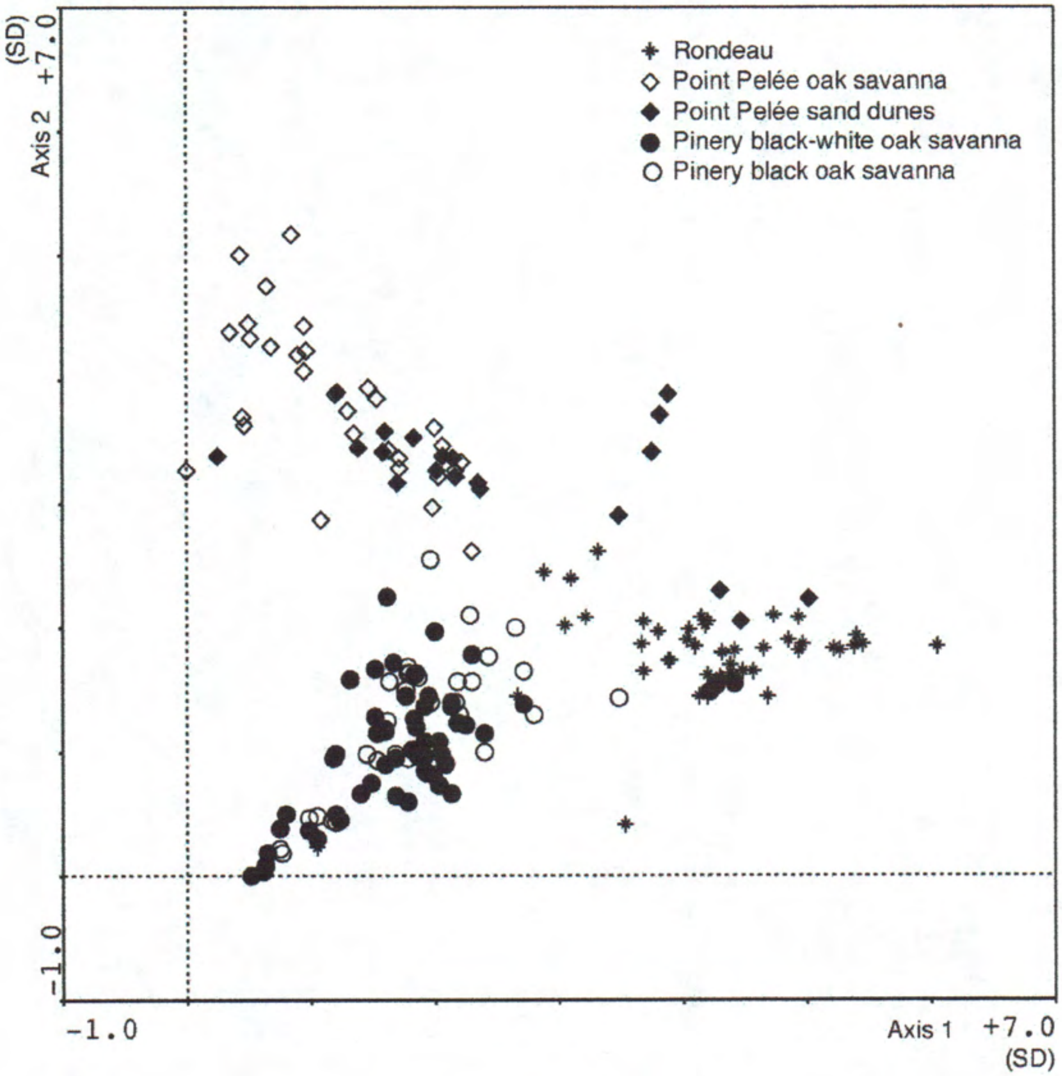

Figure 1.9: DCA diagram (axes 1 and 2) for all 3 parks.

Part Two: Recovery of Restored Cottage Sites in Point Pelée National Park

2.1 Introduction

Point Pelée National Park, and Rondeau and Pinery Provincial Parks represent some of the few remaining large fragments of Carolinian (Eastern Deciduous) forest in southwestern Ontario (Figure 1.1), where forest cover is less than 10% on a regional basis (Koh 1995, McLachlan 1997). The Carolinian zone also contains 65% of Ontario's rare plant species, with 40% restricted to this zone (Allen *et al* 1990).

Rondeau and Pinery Provincial Parks have been severely overgrazed by white-tailed deer (*Odocoileus virginianus*), and in recent years deer culls have been carried out in the attempt to reverse the degradation. One outcome of deer grazing in Rondeau appears to be an alteration of the regular process of forest regeneration. The large numbers of deer in the park eat everything in the understorey, including all of the tree seedlings that would normally grow to fill in naturally occurring canopy gaps (Bazely *et al* 1997). The story is similar in Pinery Provincial Park, where deer overgrazing has resulted in the loss of several woodland and savanna species and woodland areas that have opened up and have little or no shrub layer.

Deer overgrazing is a concern in protected areas because it can reverse succession. The major issues in the parks are the direct impact of deer overgrazing in removing particular native species and tree size classes, and indirect impacts of overgrazing which include an increase in non-native species as the forest opens up.

Point Pelée National Park has also suffered from intensive deer grazing in the past (Koh 1995), but culls to control the deer population began earlier and have been more frequent. Park managers have indicated that the preservation of natural habitat in the park must involve a landscape level approach, as the long-term ecological integrity of Point Pelée is related to the health of the regional environment. Previous studies have been conducted in and around Point Pelée to assess various approaches to habitat restoration, including efforts to promote the rate of succession of restored forest gaps (McLachlan 1997).

Identifying the nature of the relationship between light conditions and understorey plant communities is also important for restoration efforts at Point Pelée. These efforts have been ongoing for several decades in the park. Removals of cottages and roads, and reintroduction of some native species to these sites, appear to have been successful in allowing regeneration of native plant communities as the canopies have developed. However, one class of vulnerable native understorey species - spring flowering ephemerals with low dispersal capabilities - has been unable to recolonise restored sites even from nearby undisturbed sites (McLachlan 1997, McLachlan & Bazely 2001). These species are candidates for reintroduction to restored sites.

In 1994, McLachlan (1997) selected 28 former cottage and road sites in Point Pelée National Park in order to assess the success of various restoration efforts that had been conducted in the park since the 1960s. These efforts included passive restoration at some sites, where buildings and roads were removed and sites were left to recover naturally, and active restoration at other sites, where buildings and roads were removed and some and some native shrubby species were planted. Other measures included an ongoing program of deer population control beginning in 1989 (McLachlan 1997).

The present study follows the further recovery of 4 of these restored cottage sites of various ages. The plant community compositions of the sites are compared with those observed by McLachlan in 1994 (McLachlan 1997). Light levels were also measured in 2000 to investigate the relationship between light conditions and plant communities in the restored sites.

2.2 METHODS

2.2.1 Herbaceous plant communities

The restored cottage sites were originally classified according to time-since-restoration and visual estimates of soil moisture class (xeric, mesic, wet). Thirteen to 22 1m x 1m sample plots were randomly located in each site, and herbaceous species cover was recorded in late spring (late May to early June) and summer (September) 1994 and early spring (May) 1995 (McLachlan 1997).

For the present study, 4 of these sites were selected to assess recovery after a further 6 years. The sites chosen spanned the entire length of the park, and represented a range of times since restoration: Bruner (27 years since restoration, as of 2000), Ribble (24 years), Gary (12 years) and Visitor Centre (34 years) (Figure 1.3). The southeast corner of the original sample quadrats was marked in 1994, and as many of these as possible were relocated in each of the 4 sites in 2000 (Bruner: 6 quadrats, Ribble: 6, Gary: 7, Visitor Centre: 9). Percent cover of herbaceous species and woody species smaller that 40cm in height was recorded in each quadrat in early spring (May 23 – 26), late spring (June 17 – 20) and summer (August 15) 2000.

2.2.2 Light

Photosynthetically active radiation (PAR) (400 to 700 nm) was measured in the cottage sites in Point Pelée on September 1, 2000. PAR readings were taken at 5m intervals along a transect which ran diagonally across each cottage site. The length of the transect, and hence the number of light readings taken, varied with the size of the site.

A LI-191SA line quantum sensor was used in the cottage sites with corresponding readings taken in the open with a LI-190SA point sensor (LI-COR). PAR was measured at the height of the majority of herbaceous vegetation and at a height of 2m at each 5m interval along the transect. Light measurements were conducted on a clear, cloudless day, between the hours of 11:00am and 3:00pm.

2.2.3 Statistical analyses

Multivariate analysis was conducted using CANOCO version 4.0 for Windows (ter Braak & Smilauer 1998). Detrended correspondence analysis (DCA) was used to explore general relationships between the herbaceous plant communities between sites and over time, using the maximum cover of each species recorded in a season.

2.3 Results

2.3.1 Herbaceous plant communities

Site centroids in the DCA (Figure 2.1) show the relationships between the sites in terms of plant community composition. The site centroid is placed in the centre of the distribution of species found at that site (Jongman *et al* 1995). The distance between site centroids in the diagram indicates the relative similarities between the plant communities of the sites (i.e. the further apart site centroids are placed, the less similar are their plant communities). The closer the point for a species appears to a site centroid, the more likely that species is to be found at that site (i.e. the data show it to be more abundant at that site) (Jongman *et al* 1995).

The distributions of the site centroids in the DCA show that Bruner (BR) and Visitor Centre (VC) have become more similar to one another since 1994, as have Ribble (RB) and Gary (GA). These pairs of sites are separated by approximately 3 standard deviations (SD) in 2000. A distance of 4 standard deviations between sites would indicate that they had no species in common; hence, the observed spread in Figure 2.1 is considerable (Jongman *et al* 1995). The first 2 axes of the DCA respectively explain 10% and 6.3% of the observed variation in plant communities. Bruner and Visitor Centre are relatively dark sites with more shrubs and trees, while Ribble and Gary are very open, grassy sites with few shrubs and trees.

The understorey plant communities of Bruner and Visitor Centre are currently dominated by native forest understorey species such as sweet cicely (*Osmorhiza claytoni*), poison ivy (*Rhus radicans*), star-flowered solomon's seal (*Smilacina stellata*), cleavers (*Galium aparine*) and Virginia creeper (*Parthenocissus quinquefolia*), with few exotic or shade-intolerant species. Ribble and Gary are dominated by various grasses and sedges, which are typical of open areas with lots of light (Figure 2.1) (see Appendix IV for species codes used in the DCA).

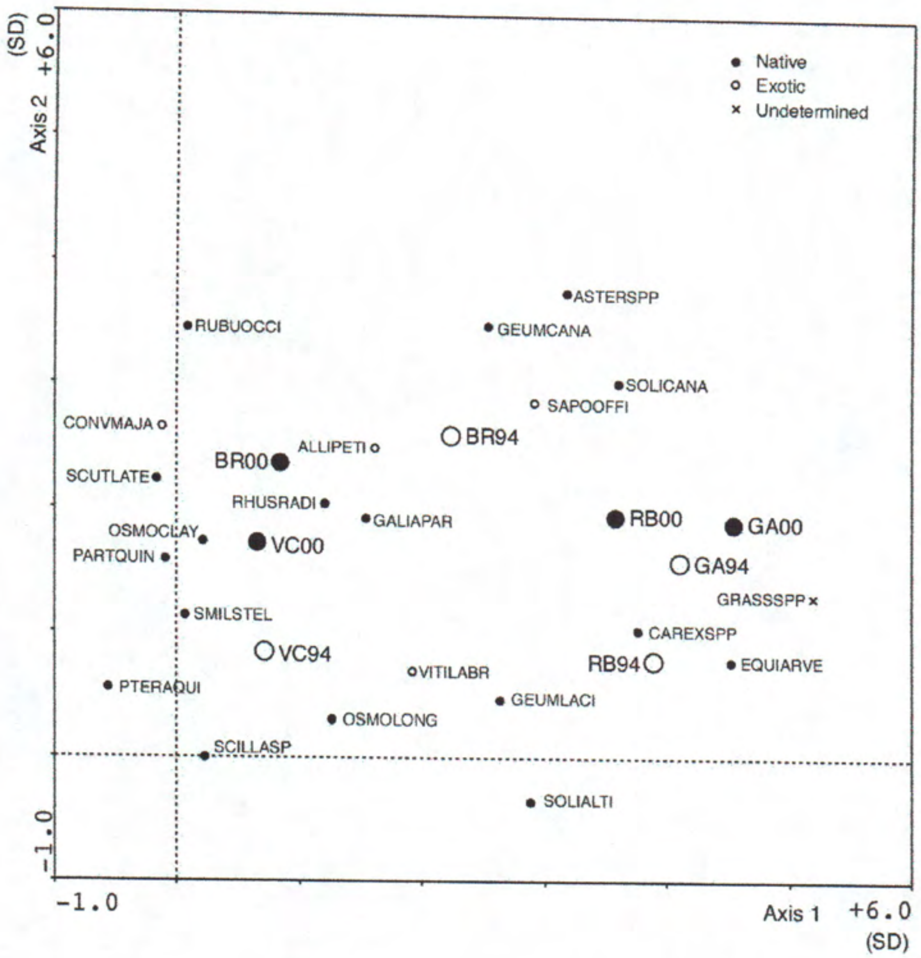

Figure 2.1: DCA of restored cottage sites in Point Pelée National Park. Site centroids are shown for the plant communities surveyed in 1994 (open circles) and 2000 (closed circles) (BR = Bruner; VC = Visitor Centre; RB = Ribble; GA = Gary). Species labels consist of the first 4 letters of the genus and species names (except where species-level identifications were not possible, in which case the label consists of the first 5 letters of the genus [or common name of plant type] followed by SPP).

The general distributions of native and exotic species have changed in some of the cottage sites since 1994 (Figure 2.2). There was little change in the relative distributions of native and exotic plants over time in both Visitor Centre and Bruner. The proportion of grasses and sedges in those sites also did not change. Gary showed an increase in grasses and sedges over time, along with a decrease in exotic dicots and ferns. There was little change in native dicots and ferns in Gary. The proportion of grass and sedge cover in Ribble declined slightly between 1994 and 2000, accompanied by an equivalent increase in exotic dicots and ferns. There was no change in native species cover in Ribble over time.

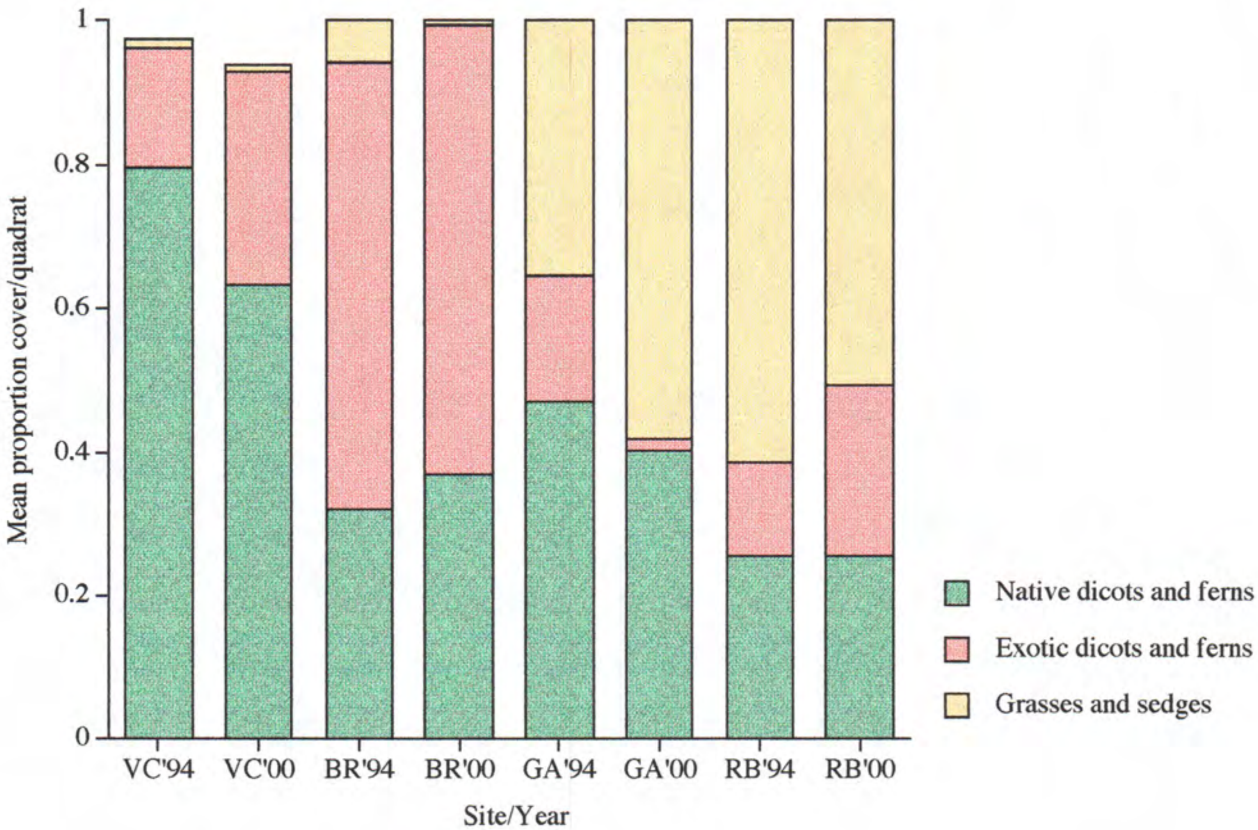

Figure 2.2: Relative proportions of native and exotic species, and grasses and sedges present in restored cottage sites in Point Pelée National Park sampled in 1994 and 2000.

2.3.2 Light and plant communities

Light measured in Gary and Ribble was considerably higher than in Visitor Centre and Bruner. High light levels were associated with high proportions of grasses and sedges in the plant communities, while they were virtually absent in the dark sites (Figure 2.3).

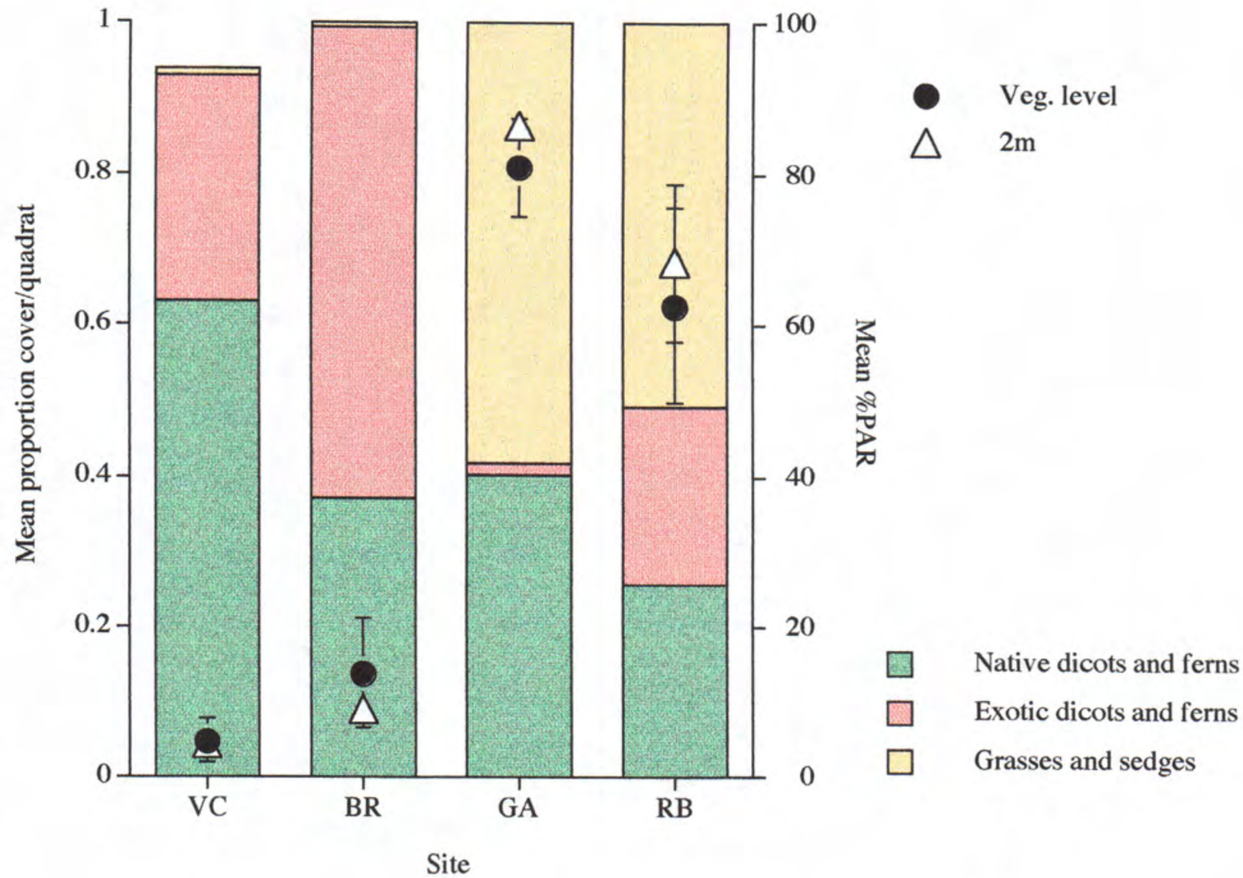

Figure 2.3: Mean PAR (as % of PAR in open) measured at vegetation level and 2m in restored cottage sites in Point Pelée National Park, and relative proportions of native and exotic species, and grasses and sedges measured in 2000.

2.4 Conclusions and Recommendations

The DCA analysis shows that all 4 cottage sites experienced changes in plant community composition between 1994 and 2000. The separation between the pairs of sites (VC and BR; RB and GA) along the first DCA axis indicates a considerable difference, which has increased over time. The small percentage of the variation in the data explained by the first 2 DCA axes is, nonetheless, an important result. Often, species data can be quite noisy, and the amount of variation able to be explained by this analysis is often low, although it does provide useful information about the communities (ter Braak & Smilauer 1998).

Most changes in plant community composition over time were small within a site, with the exception of a larger decrease in exotic species accompanied by a large increase in grasses and sedges in Gary. The most apparent result from the analyses is the large proportions of grasses and sedges in Gary and Ribble, as opposed to virtually none in Visitor Centre and Bruner. This is strongly related to light levels in the sites (Figure 2.3), which is the likely variable responsible for the gradient along the first DCA axis (Figure 2.1).

Gary and Ribble are very open sites, which receive abundant light, and contain high proportions of grasses and sedges, which are typical of dryer, more open areas. These sites are strongly tending towards naturally open, dry areas, and are likely to continue along this trajectory over time. It is recommended that these be allowed to follow this trajectory, and efforts to restore Carolinian forest be concentrated in other sites with conditions more typical of that habitat type.

The plant communities in Visitor Centre and Bruner receive very little light and are dominated by shade adapted understorey species, both native and exotic. While there are many native Carolinian forest species in these sites, there remains a general lack of those classified as most vulnerable by McLachlan and Bazely (2001). The fact that many native understorey species have managed to return and survive in these sites indicates that site conditions may allow reintroduction of some vulnerable species that have not been able to disperse to the restored sites on their own. The continuing presence of exotic species, however, gives rise to the issue of competition. The focus of the next section of this report is a transplant experiment that was conducted to investigate the performance of introduced native understorey species in the presence of different light conditions and levels of competition.

PART THREE: EXPERIMENTAL REINTRODUCTION OF VULNERABLE NATIVE HERBACEOUS AND WOODY SPECIES TO A MODEL SOUTHERN ONTARIO CAROLINIAN FOREST

3.1 INTRODUCTION

While some recovery has been observed in the cottage sites in Point Pelée National Park, there remains a general lack of spring flowering ephemerals that had been classified as vulnerable by McLachlan and Bazely (2001). Given the long time during which recovery has been occurring in these sites, the missing vulnerable species have been identified as candidates for reintroduction.

An afforestation experiment in a post-agricultural field at Sturgeon Creek, approximately 2km north of Point Pelée, resulted in successful introduction of 3 native tree species - silver maple (*Acer saccharinum*), green ash (*Fraxinus pennsylvanica*) and bur oak (*Quercus macrocarpa*) - in 1994, and recommendations were made to attempt introduction of native understorey species at this site. A major prediction developed during this research is that by promoting increased canopy cover and lower light levels, cover of light-adapted, non-native (exotic) species will be reduced (McLachlan 1997).

The specific objective of the present study was to determine whether the establishment and growth of some native woodland species is limited more by dispersal than by light conditions and competition from non-native species. An experiment introducing native tree species and herbs to the Sturgeon Creek site was carried out to determine how they would survive and grow in a young, early successional forest.

3.2 METHODS

Differential success of the trees originally planted at Sturgeon Creek resulted in very open, light patches with little canopy cover, as well as some very shady patches with dense cover. Five open plots and 5 shady plots were chosen in October 1999 for transplant experiments to examine the role of light and competition from weeds in the growth and survival of rare, endangered or vulnerable Carolinian forest species.

3.2.1 Tree transplants

Saplings of 3 species of COSEWIC (Committee on the Status of Endangered Wildlife in Canada) listed trees - red mulberry (*Morus rubra*) (n=20), blue ash (*Fraxinus quadrangulata*) (n=10) and hoptree (*Ptelea trifoliata*) (n=10) - were planted in the selected open and shady plots in autumn (October 17 and November 6) 1999. Each plot received 2 *M. rubra*, and 1 each of *P. trifoliata* and *F. quadrangulata*. The trees were sorted so that both shady and light plots received a selection of trees of similar sizes. The *M. rubra* saplings were donated by Rondeau Provincial Park, and were cultivated at Ridgetown College, propagated from trees originating from Rondeau Provincial Park, Point Pelée National Park and Pelée Island. The *P. trifoliata* and *F. quadrangulata* saplings were cultivated in Point Pelée National Park, propagated from trees within the park. The heights of all trees that survived the winter were measured in spring (May 29) and again in late summer (August 15) 2000.

Nursery seedlings of 2 additional species - pawpaw (*Asimina triloba*) (n=18) and Kentucky coffeetree (*Gymnocladus dioicus*) (n=18) - were planted in the same 10 plots in spring (May 12 - 13) 2000. Four shady plots and 4 light plots each received 2 of each species, while 1 of each was planted in each of the remaining 2 plots. Because of their small size, each seedling was protected after planting with a small chicken wire exclosure. Heights were measured in spring (May 29) and summer (August 15) 2000.

3.2.2 Woodland herb transplants

The same 10 plots used for the tree transplants were also used for a transplant experiment using 2 native Carolinian herbaceous species - Virginia waterleaf (*Hydrophyllum virginianum*) and yellow violet (*Viola pubescens*) - both classified as vulnerable to disturbance by McLachlan and Bazely (2001).

The experiment was designed to examine the effect of 2 factors - light and competition from weeds - on growth and survival of introduced forest herbs. The light factor had 3 levels: no shade (naturally open plots), artificial shade (shade cloth placed over transplant blocks within naturally open plots) and canopy shade (leaf cover in naturally shady plots). The weed cover treatment had 2 levels: no weeds (all weed cover within a transplant block was clipped at ground level on several occasions throughout the field season) and weeds (no weed cover was removed). The weed treatments were applied within each light treatment.

In each of the 5 open plots, a 2m x 2.5m exclosure was built using chicken wire with a mesh size of 2 inches (Figure 3.1c). The 2.5m side was oriented west-east, and the artificial shade (S) and no shade (NS) treatments were assigned randomly to either the west or the east side. The extra 0.5m width of the exclosure acted as a buffer area to avoid indirect effects of the artificial shade on the adjacent unshaded treatment blocks. Within each light treatment, the weed (W) and no weed (NW) treatments were randomly assigned to either the north or south transplant block (each 1m x 1m).

Within each of the 5 shady plots, a 2m x 1m exclosure was built, and the weed (W) and no weed (NW) treatments were randomly assigned to either the north or south transplant block (each 1m x 1m) (Figure 3.1d). The only light treatment here was natural canopy shade (CS).

Each transplant block received 3 *H. virginianum* and 3 *V. pubescens* individuals. The *H. virginianum* transplants were obtained from one site within Point Pelée National Park, and were considered to be from a single population. The *V. pubescens* transplants were obtained from the Hillman Sandhills woodlot, approximately 7 km northeast of Point Pelée, and were also considered to be from a single population.

Controls were established within the site of origin for each transplant species. Five areas were chosen wherever at least 6 plants of the same species were found growing close together. Within each of these areas, 3 individuals were marked and left alone (Figure 3.1a), and 3 were dug up and replaced to control for the effect of transplantation (Figure 3.1b). A chicken wire exclosure was erected around each set of 6 control plants.

The construction of exclosures and transplantation of the plants was conducted in early May (6 - 13) 2000. The tallest leaf of each plant was marked, and the height from the ground to the base of the leaf was measured. The height of the same leaf was measured on subsequent sampling dates until it died, at which time a new leaf (currently tallest) was marked and measured. The number of live leaves currently on each plant was also recorded on each sampling date. These measurements were repeated every 12 to 14 days from May 13 to August 19 2000, or until an individual plant died.

3.2.3 Light

Photosynthetically active radiation (PAR) (400 - 700 nm) was measured in each transplant block and each control block on a clear, cloudless day in late summer (August 31) 2000, using a LI-191SA line quantum sensor. Corresponding readings were taken in the open with a LI-190SA point sensor (LI-COR). Light was measured in each block once, just above the transplants or control plants.

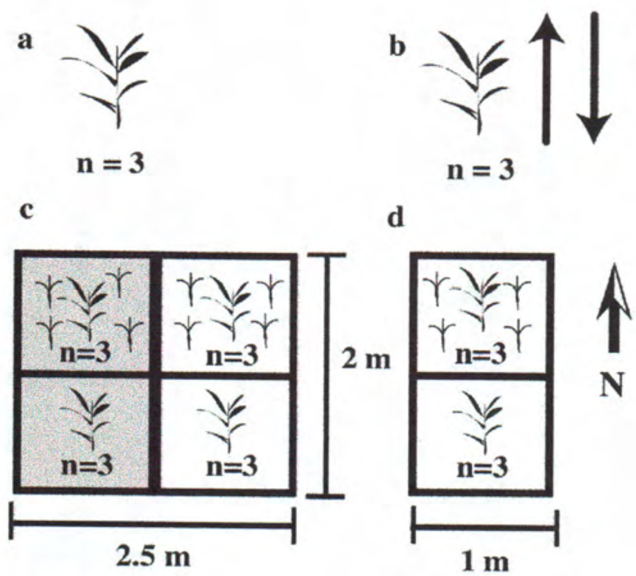

Figure 3.1: Layout of herb transplant experiment. Each control exclosure contained 3 unmoved (a) and 3 moved (b) individuals. *H. virginianum* controls were located in Point Pelée National Park and *V. pubescens* controls were located in Hillman Sandhills. Open plots in Sturgeon Creek contained exclosures divided into shaded (gray area) and unshaded halves, each of which contained a weedy and a weedless block (c). Plots under canopy shade (d) contained a weedy and a weedless block. Each transplant block contained 3 individuals of each species.

3.2.3 Statistical analyses

3.2.3.1 Tree transplants

A Fisher exact probability test (Sokal & Rohlf 1995) was applied to compare the survival of each tree species between open and shady plots, using Systat version 5.1 for MacIntosh (SYSTAT, Inc. 1990).

Two-sample, unpaired t-tests were applied to compare the total growth of each species in open versus shady plots, using STATVIEW SE+Graphics™ version 1.02 for MacIntosh (Abacus Concepts, Inc. 1988).

3.2.3.2 Woodland herb transplants

Statistical analyses were performed on data collected from only those individuals that survived the entire season. For each species, the 8 treatment combinations were ranked according to the number of survivors using a Kruskal-Wallis test. This is a non-parametric alternative to the one-way ANOVA, and can be applied in cases where the data are not normally distributed, sample sizes are very different or the parametric assumption of homogeneity of variances cannot be met. The Kruskal-Wallis test is 95% as powerful as the parametric ANOVA (Zar 1996).

A one-sample t-test was performed to compare the difference between the number of *H. virginianum* and *V. pubescens* survivors over the treatments. This analysis was performed using STATVIEW SE+Graphics™ version 1.02 for MacIntosh (Abacus Concepts, Inc. 1988).

3.3 Results

3.3.1 Tree transplants

The survival of most of the tree species was not significantly different in the open versus shady plots (*M. rubra* $p = 1.000$, *F. quadrangulata* $p = 1.000$, *P. trifoliata* $p = 0.542$). *A. triloba*, however, did appear to survive somewhat better in the shade, although the difference was not quite significant ($p = 0.082$). All *G. dioicus* individuals survived (Figure 3.2).

All tree species grew over the season in the shady plots (Figure 3.3). Most grew less in the open plots (with the exception of *M. rubra*, which grew slightly more in the light). The only significant differences in growth between open and shady plots were observed for *A. triloba* ($t_{0.05(2), 12} = -2.715$, $p = 0.188$) and *G. dioicus* ($t_{0.05(2), 16} = -3.25$, $p = 0.005$), where survivors of both grew more in shady plots, with virtually no growth in open plots.

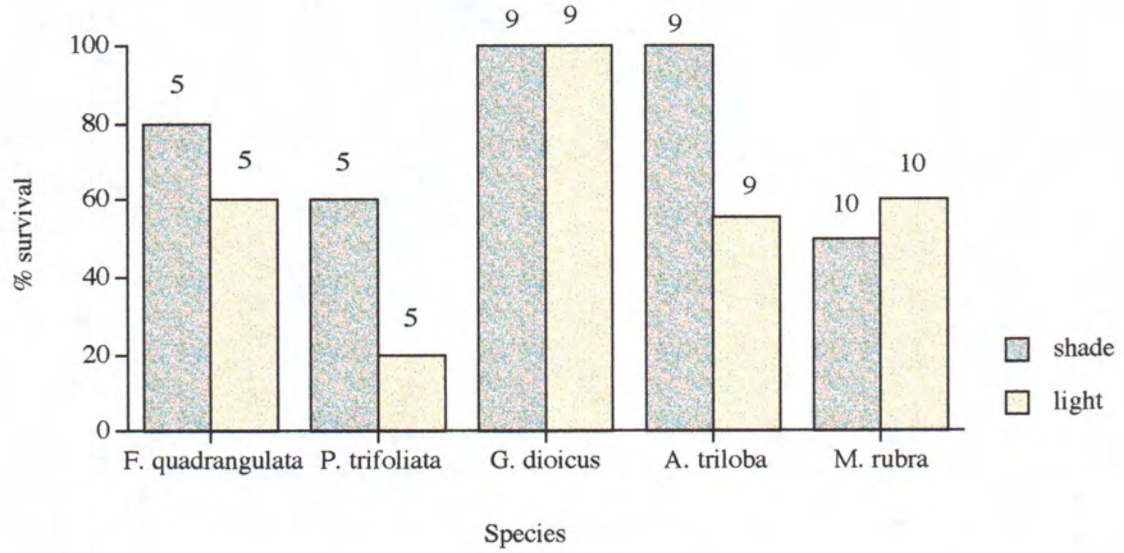

Figure 3.2: Survival of 5 native Carolinian tree species transplanted into shady and open plots in Sturgeon Creek (the numbers above the bars indicate number of individuals planted).

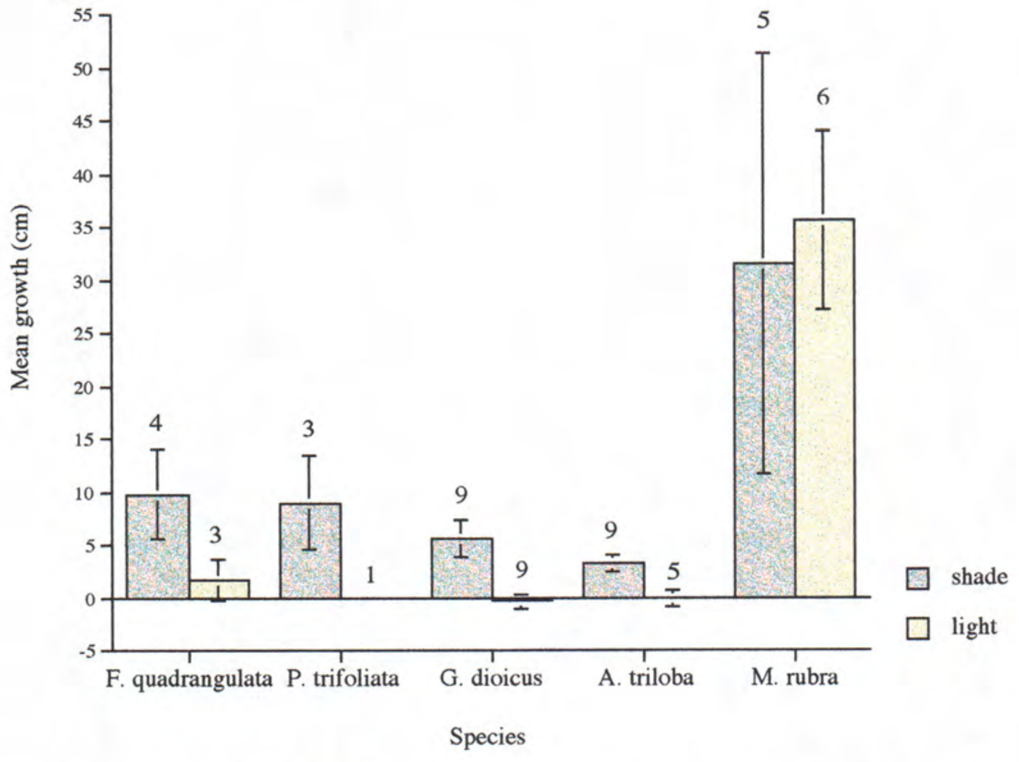

Figure 3.3: Mean (± SE) growth of surviving transplanted trees from May 29 to August 15, 2000 (the numbers above the bars indicate the number of individuals surviving). Differences were significant only for *A. triloba* ($t_{0.05(2), 12} = -2.715$, $p = 0.188$) and *G. dioicus* ($t_{0.05(2), 16} = -3.25$, $p = 0.005$).

3.3.2 Woodland herb transplants

V. pubescens survived better than *H. virginianum* in all transplant blocks within the light plots at Sturgeon Creek, as well as in the control plots. *H. virginianum* appeared to have higher survivorship than *V. pubescens* in the transplant blocks with natural canopy shade (Figure 3.4). However, the one-sample t-test showed that the differences in number of survivors between the species were not significant ($t_{0.05(2),7} = -0.861$, $p = 0.4178$).

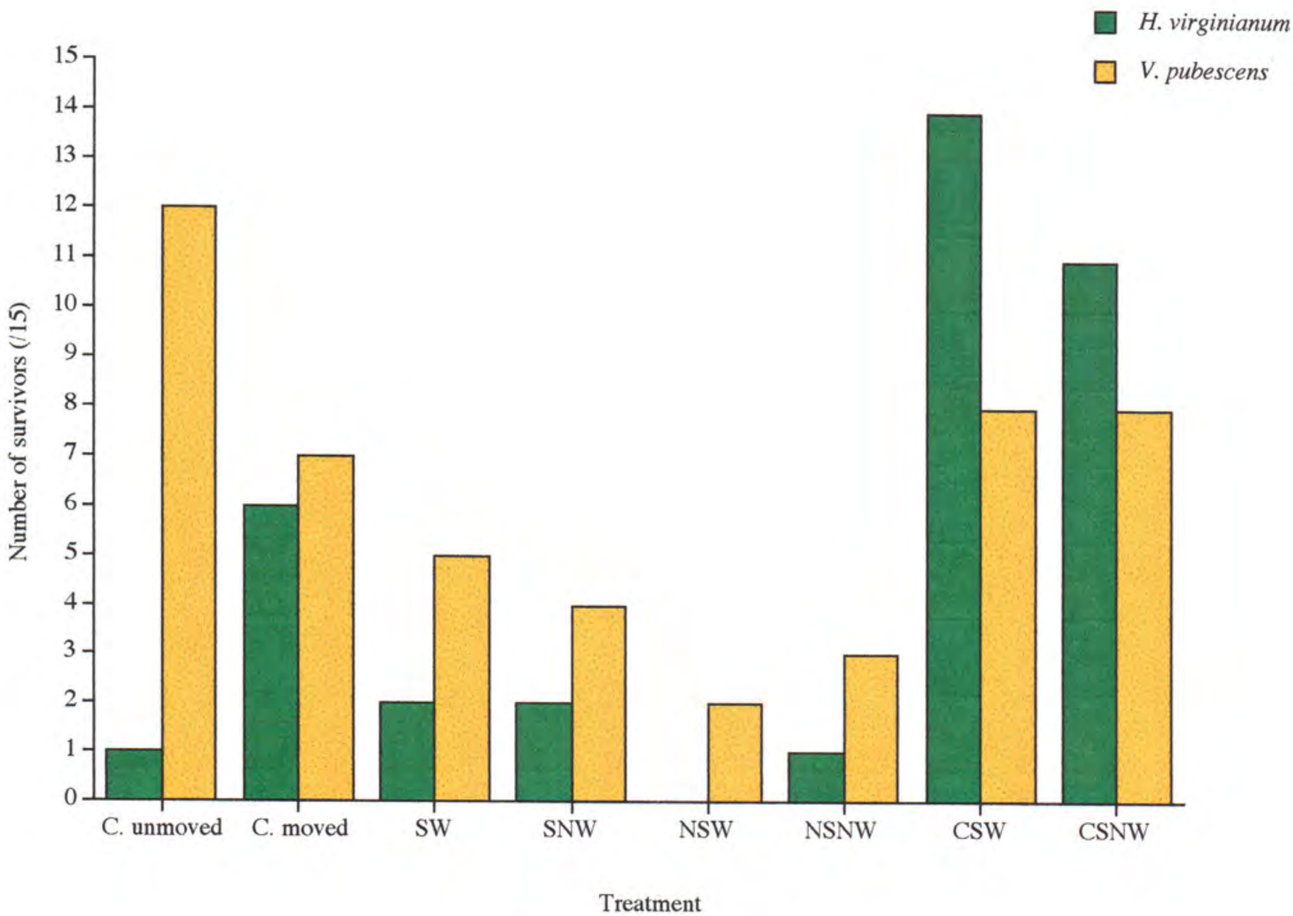

Figure 3.4: Total number of plants surviving to the end of the season under each treatment combination (out of 15 originally planted in each treatment). The difference between the numbers of *V. pubescens* and *H. virginianum* surviving did not vary significantly over the treatments (one-sample t-test; $t_{0.05(2),7} = -0.861$, $p = 0.4178$).

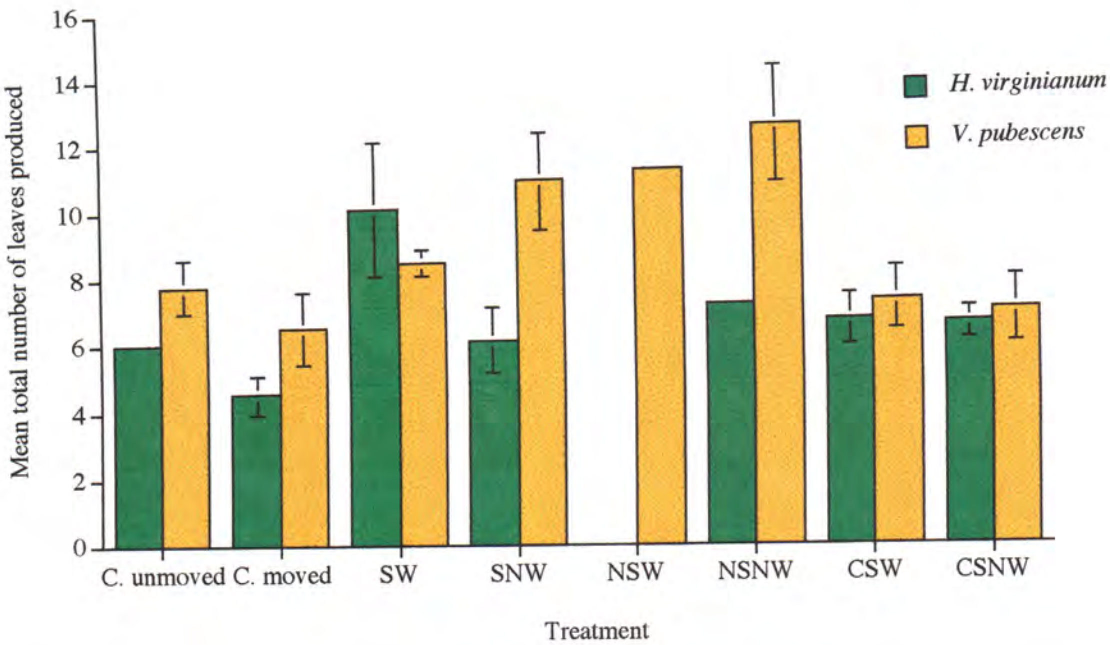

Figure 3.5: Mean (± SE) total number of leaves produced per surviving individual throughout the season under different treatment combinations.

3.3.2.1 Virginia waterleaf (*Hydrophyllum virginianum*)

The survival of *H. virginianum* was significantly greater in the transplant plots under natural canopy shade (CSW and CSNW) than in any of the transplant blocks within light plots (both unshaded and artificially shaded), when the Kruskal-Wallis rank statistic was corrected for ties ($H = 26.989$; $p = 0.0003$) (Figure 3.4). Interestingly, the individuals transplanted to the canopy shade plots in Sturgeon Creek also survived much better than the control plants, both moved and unmoved. In fact, the control plants that were dug up and replaced had a higher survival rate than those that were undisturbed.

The mean total number of leaves produced per plant by the end of the season varied only slightly among the treatments (Figure 3.5).

The mean number of live leaves per plant declined to various extents under most treatments throughout the season (Figure 3.6). An exception was the no shade+no weeds (NSNW) treatment in the open Sturgeon Creek plots, in which the mean number of live leaves per plant increased for most of the season, and dropped back down near the end of the season to a number similar to that observed on the first sampling date. The leaf number under the control unmoved treatment declined considerably over the season, but it should be noted that these data are from one individual, the only control unmoved plant to survive the season. Leaf number also decreased throughout the season in the artificially shaded blocks, more so when weeds were left in the blocks. In both cases (weeds and no weeds), the results are based on data from only two survivors in each treatment. The smallest declines in mean leaf number per plant were observed in the treatment blocks under natural canopy shade (Figure 3.6).

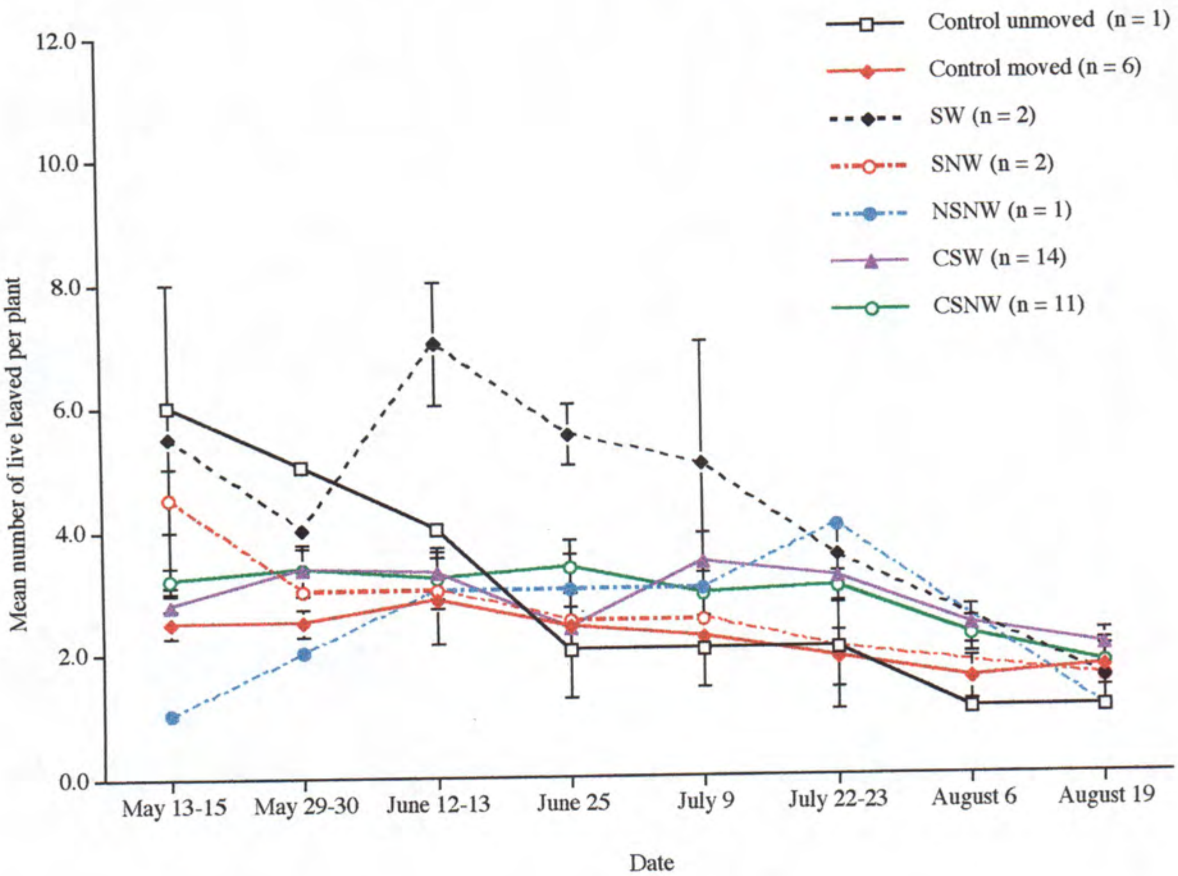

Figure 3.6: Mean (± SE) number of live leaves per plant observed on surviving *H. virginianum* individuals on sampling dates throughout the season.

3.3.2.2 Yellow violet (*Viola pubescens*)

There was no significant difference in survival of *V. pubescens* among the transplant and control treatments, when the Kruskal-Wallis rank statistic was corrected for ties ($H = 13.901$; $p = 0.053$) (Figure 3.4).

The mean total number of leaves produced per plant over the season varied slightly among the treatments (Figure 3.5).

The mean number of live leaves per plant declined in all treatments to varying extents (Figure 3.7). The greatest decreases in leaf number were observed in the unshaded transplant blocks within open plots. Moderate early declines in leaf number were observed in the artificially shaded blocks in the open plots. Those with weeds remaining in the blocks experienced a slight increase in leaf number towards the end of the season (although this increase did not reach as high as the original number of leaves early in the season). The transplants in the naturally shaded plots showed a gradual decrease in mean leaf number similar to that shown by the unmoved control plants. The moved control plants had a slightly sharper early decline in leaf number, which leveled off somewhat by mid-season (Figure 3.7).

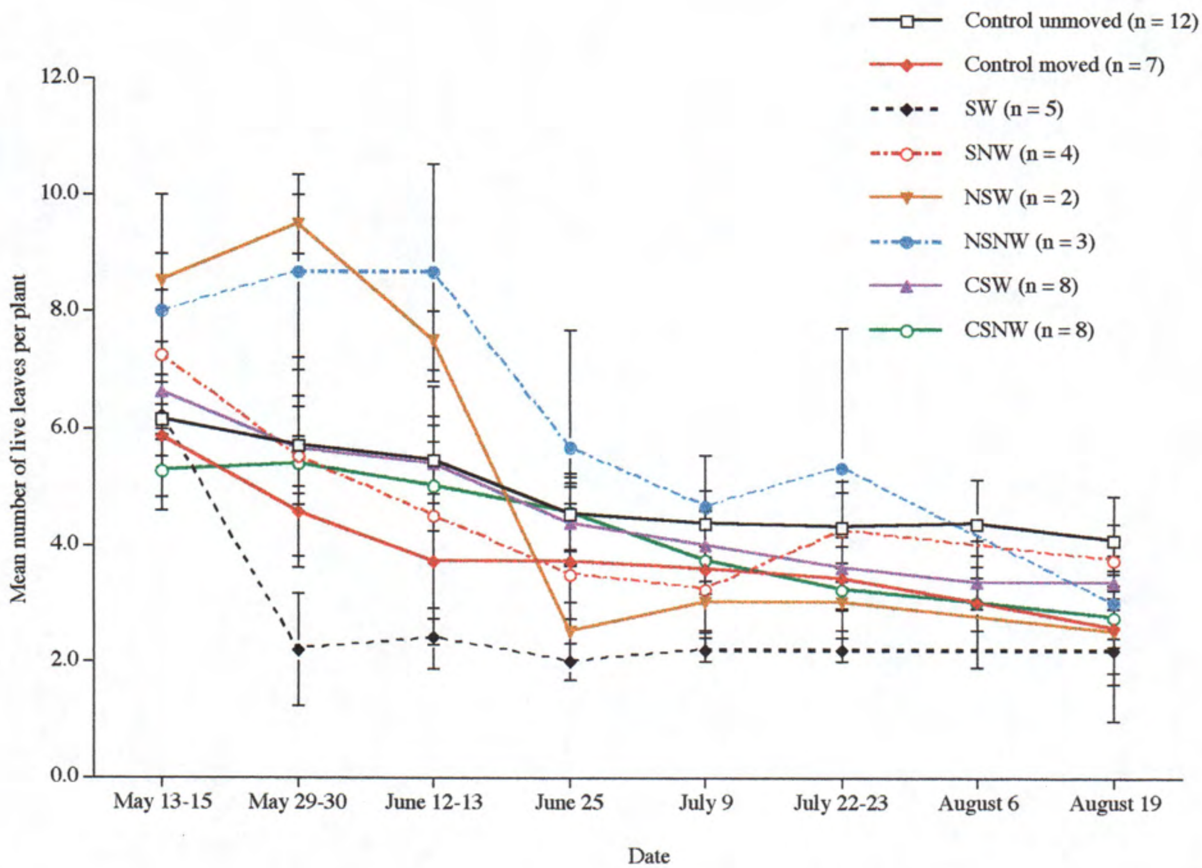

Figure 3.7: Mean (± SE) number of live leaves per plant observed on surviving *V. pubescens* individuals on sampling dates throughout the season.

3.3.3 Light

Light levels were highest in the unshaded transplant blocks where weeds were removed. Light was also high in the unshaded blocks where no weeds were removed, and only slightly lower in the artificially shaded blocks with and without weeds. Light levels were lowest in the control sites. The light in the transplant blocks under canopy shade was at most half that of the blocks in the open plots (Table 3.1).

Table 3.1: Mean (± SE; n = 5 for all treatments) light readings taken under clear, cloudless skies in Sturgeon Creek transplant blocks on August 31, 2001. Direct readings (PAR) as well as readings as a percentage of corresponding readings in full sunlight (% PAR) are shown.

TREATMENT	MEAN (± SE) PAR (μmol/m²/s)	MEAN (± SE) % PAR
***H. virginianum* control**	56.89 (± 37.53)	3.62 (± 2.39)
***V. pubescens* control**	6.30 (± 2.41)	0.37 (± 0.14)
SW	336.86 (± 94.35)	23.05 (± 6.85)
SNW	453.85 (± 80.87)	30.54 (± 5.62)
NSW	607.26 (± 109.60)	41.60 (± 7.60)
NSNW	819.82 (± 175.69)	54.45 (± 11.36)
CSW	193.01 (± 148.81)	12.54 (± 9.68)
CSNW	158.51 (± 131.91)	10.30 (± 8.58)

3.4 Conclusions and Recommendations

3.4.1 Tree transplants

While most of the native tree transplants survived equally well in both open and shady plots, most survivors grew more over the season in the shady plots. This result was significant only for *G. dioicus* and *A. triloba*, although the only other species that grew slightly more in open plots was *M. rubra*. The survival and growth results suggest that reintroduction of these species will have reasonable success under most light conditions present in sites within Point Pelée. This is encouraging for efforts to restore native woody and herbaceous plant communities in park sites. In particular, these tree species can be planted in sites that are currently too open to allow recovery of native forest understorey species. This will not only increase populations of these rare and endangered tree species, but will also, with time, provide more shady conditions which may promote the return of some desired understorey species.

It is especially significant that transplanted *M. rubra*, a very rare Carolinian tree species, survived and grew so well in Sturgeon Creek. Given the extremely low numbers of this species remaining in Ontario's Carolinian zone, it would be worthwhile to attempt reintroduction of *M. rubra* to several Southern Ontario sites that currently have very small remaining populations. A major concern, however, is the proximity of populations of white mulberry (*M. alba*), a quite successful exotic species that is known to hybridise with *M. rubra*. If reintroduced *M. rubra* are to succeed, measures must be taken to protect it from hybridisation. Information is needed on the distance that *M. alba* pollen is able to travel, and measures to remove *M. alba* individuals/populations should be considered, or *M. rubra* reintroductions should be restricted to areas distant from existing *M. alba* populations.

3.4.2 Woodland herb transplants

While survival of *V. pubescens* did not differ significantly among treatments, they did survive a little better under natural canopy shade. In contrast, survival of *H. virginianum* was significantly higher under natural canopy shade. The presence of weeds appeared to have little effect on survival or leaf production in either species. Most observed differences appear to be associated with light levels, the effects of which appear to be slightly affected by presence or absence of weeds (i.e. surrounding weeds further reduce the light reaching the transplants). It seems that most of the effect that weeds may have had in this experiment was associated with how they affected light levels (see Table 1), with no clear indications that competition by weeds may have had an effect.

While results of this experiment may indicate that there is a threshold light range below which these species survive and grow better (measured light levels under natural canopy shade were approximately half those under artificial shade), light is not the only important factor affecting these species. Along with much lower light levels, a tree (and shrub) canopy provides other protection to understorey species. In particular, interception of rainfall by the canopy affects the amount of rainfall that reaches the understorey plants. While it was not quantified in this experiment, several periods of very heavy rainfall occurred in the area during the season. On several occasions, severe flooding was observed in the transplant exclosures in the open plots, whereas nearby shady plots had much less standing water. It was apparent while in the field that this flooding was responsible for some of the mortality observed in the open plots. The artificial shading did not intercept enough rainfall to make an observable difference in standing water between these blocks and adjacent unshaded blocks.

There was no clear effect of transplantation itself on the plants. While the control moved *H. virginianum* individuals actually survived better than those controls that were not moved, those that were transplanted into the canopy shade plots in Sturgeon Creek had much higher survival rates. It appears that for this species, the effect of moving the plants was relatively unimportant in comparison to the environmental conditions in which they were placed. The control moved and all the transplanted *V. pubescens* had lower survival rates than the control unmoved individuals. In this case, there may be some effect of transplantation interacting with the environmental conditions, however the high mortality of transplants in the open plots due to flooding makes it difficult to distinguish the relative importance of these effects.

The results of this experiment indicate that reintroductions of vulnerable, native understorey species can be successful, but it is important to provide conditions conducive to their establishment and success. A canopy cover is necessary to provide protection from excessive light and rainfall. Simply providing an appropriate canopy cover and protecting sites from overgrazing, may in fact be enough to ensure successful recovery of desired species. Under these conditions, the species in the experiment appeared to have little trouble competing with weeds and exotic species present.

APPENDICES

Appendix I: Latin and common names and sites of occurrence [PTP= Point Pelee National Park 2000 RON=Rondeau Provincial Park 2000 PIN=Pinery Provincial Park 1994/99/2000] of Oak Savanna species.

Species		
Latin name	**Common name**	**Site of Occurrence**
Acer saccharum	Sugar maple	PTP
Achillea millefolium	Common yarrow	PTP, RON
Alliaria petiolata	Garlic mustard	PTP, RON
Ambrosia artemesiifolia	Common ragweed	PTP, RON
Amelanchier sp.	Serviceberry	PIN, PTP
Amphicarpa bracteata	American Hog-peanut	RON
Andropogon gerardii	Big bluestem	RON, PTP, PIN
Anemone canadensis	Canada anemone	RON, PTP
Aquilegia canadensis	Wild columbine	RON, PTP, PIN
Arctostaphylos uva-ursi	Bearberry	PIN
Arenaria serpyllifolia	Thyme-leaf sandwort	PTP
Arenaria stricta	Rock sandwort	PTP
Artemisia caudata	Beach wormwood	PTP
Artemisia sp.	Wormwood	PTP
Asclepias sp.	Common milkweed	RON
Asclepias tuberosa	Butterfly milkweed	RON
Aster spp	Aster species	RON, PTP
Berberis thunbergii	Japanese barberry	RON
Blephilia hirsuta	Hairy woodmint	PIN
Campanula americana	Tall bellflower	PTP
Carex pensylvanica	Pennsylvania sedge	PTP
Carex spp	Sedge species	PIN, RON, PTP
Carpinus /Ostrya	Blue-beech/Hop-hornbeam	RON
Carpinus caroliniana	Blue beech	PTP, RON
Celtis spp	Hackberry	PIN
Centaurea maculosa	Spotted Starthistle	PTP
Cerastium sp.	Chickweed	PTP
Circaea quadrisulcata	Enchanter's nightshade	PTP, RON
clumped grass (*Festuca* or hair grass)	Fescue	PIN, PTP
Comandra umbellata	Bastard toad-flax	PIN
Compositae (family)		PIN, PTP
Cornus alternifolia	Alternate-leaf dogwood	PTP
Cornus rugosa	Roundleaf dogwood	PTP
Cornus sp.	Dogwood	PIN, PTP, RON
Deschampsia flexuosa	Crinkled hairgrass	PIN
Desmodium canadense	Showy tick-trefoil	RON
Desmodium paniculatum	Panicled tick-trefoil	RON
Desmodium sp.	Tick-trefoil	RON
Epipactis helleborine	Eastern helleborine	PIN
Equisetum arvense	Common horsetail	RON
Equisetum sp.	Horsetail	PIN, RON
Eupatorium hyssopifolium	Boneset	RON

Euphorbia corollata	Flowering spurge	RON
Euphorbia esula	Leafy spurge	PIN
Fagus grandifolia	American beech	RON
Festuca sp.	Fescue	RON
Fragaria vesca	Wood strawberry	PTP
Fragaria virginiana	Virginia strawberry	PIN,
Fraxinus americana	White ash	PTP, PIN
Galium aparine	Catchweed bedstraw	PIN
Galium asprellum	Rough bedstraw	RON
Galium circaezans	Wild licorice	PTP
Galium pilosum	Hairy bedstraw	PIN, PTP, RON
Galium triflorum	Sweet-scent bedstraw	RON, PTP, PIN
Gaultheria hispidula	Creeping snowberry	PIN
Gaultheria procumbens	Teaberry (Wintergreen)	PIN
Geranium maculatum	Wild geranium	RON, PTP, PIN
Geranium robertianum	Herb robert	RON, PTP, PIN
Geum canadense	White avens	PTP
Geum laciniatum	Rough avens	RON
Geum sp.	Avens	RON PIN
Graminae (family)	grasses	PIN, RON, PTP,
Hamamelis virginiana	American witch-hazel	PIN, PTP
Helianthus divaricatus	Woodland sunflower	PIN, PTP, RON
Hepatica sp.	Hepatica	PIN
Hieracium pratense	Field hawkweed	PIN, RON
Hieracium sp.	Hawkweed	PIN, PTP
Hieracium venosum	Rattlesnake Hawkweed	PIN
Ipomea pandurata	Wild potato vine	PTP
Iris versicolor	Multi-coloured blue flag	RON
Juniperus communis	Ground juniper	PIN, PTP
Juniperus virginiana	Eastern redcedar	PIN, PTP
Krigia virginica 94?	Dwarf dandelion	PIN
Lactuca biennis	Tall blue lettuce	PTP
Lactuca canadensis	Canada lettuce	PTP
Lespedeza hirta	Hairy bush-clover	PIN, PTP
Liatris sp.	Blazing star	RON
Lilium sp.	Wood lily	RON
Lindera benzoin	Spicebush	RON
Liriodendron tulipifera	Tulip tree	PIN, RON
Lithospermum canescens	Hoary Puccoon	PIN, PTP
Lonicera dioica	Mountain honeysuckle	PIN, PTP
Lonicera japonica	Japanese honeysuckle	RON
Lysimachia ciliata	Fringed loosestrife	RON
Lysimachia terrestris	Swamp loosestrife	PTP
Maianthemum canadense	Canada mayflower	PIN, PTP, RON
Marrubium vulgare	Common horehound	PIN, PTP
Melampyrum lineare	American cow-wheat	PIN, PTP
Melilotus alba	White sweet clover	PTP, RON
Melilotus officinalis	Yellow sweet clover	PTP
Monarda fistulosa	Wild bergamot	RON
Onoclea sensibilis	Sensitive fern	RON
Orchis (family)	Orchids	PTP
Osmorhiza claytonii	Sweet cicely	PIN, PTP

Ostrya virginiana	Eastern Hop-hornbeam	RON
Oxalis sp.	Wood-sorrel	PIN
Panic clandestine	Broadleaf panic grass	PIN
Parthenocissus quinquefolia	Virginia creeper	PIN, PTP, RON
Pedicularis canadensis	Early wood lousewort	PIN, PTP
Pedicularis lanceolata	Swamp lousewort	RON
Plantago sp.	Plantain	PIN
Poa compressa	Canada bluegrass	PIN
Poa pratensis	Spear grass	PIN
Polygala polygama	Racemed milkwort	PIN, PTP
Polygama senega	Seneca snakeroot	RON
Polygonatum biflorum	Smooth solomon's seal	PIN
Polygonatum canaliculatum	Great solomon's seal	PTP
Polygonatum pubescens	Downy solomon's-seal	RON
Prenanthes alba	White rattlesnake-root	PIN
Prunella vulgaris	Self-heal or Heal-all	PIN
Prunus serotina	Black cherry	PIN, PTP
Prunus virginiana	Choke cherry	PIN
Pteridium aquilinum	Bracken fern	PIN
Pycnanthemum pilosum	Hairy mountain mint	RON
Quercus alba	White oak	PIN, PTP
Quercus muhlenbergii	Chinquapin oak	PIN
Quercus prinoides	Dwarf chinquapin oak	PIN, PTP
Quercus rubra	Red oak	PIN, PTP
Quercus velutina	Black oak	PIN, RON, PTP
Ranunculus abortivus	Small-flowered crowfoot	PIN
Rhus aromatica	Fragrant sumac	PIN, PTP
Rhus radicans	Poison ivy	PIN, PTP
Ribes cynosbati	Prickly gooseberry	
Rosa blanda	Smooth rose	PTP
Rosa multiflora/Carolina?	Multiflora/Pasture rose	PTP, RON
Rosa rugosa	Rugosa rose	PTP
Rubus idaeus	Wild red raspberry	PIN
Rubus occidentalis	Thimbleberry	RON
Rudbeckia serotina (=hirta)	Black-eyed susan	PIN, RON
Rumex crispus	Curled dock	PIN
Salix bebbiana	Bebb's billow	PIN
Sanguinaria canadensis	Bloodroot	PIN
Sanicula marilandica	Black snakeroot	PIN
Saponaria officinalis	Bouncing bet	PTP
Sassafras albidum	Sassafras	PIN, RON
Satureja vulgaris (Clinopodium vulgar)	Wild basil	PIN, RON
Scutellaria sp.	Small skullcap	PTP
Senecio obovatus	Roundleaf ragwort	PIN, PTP, RON
Senecio pauperculus	Balsam ragwort	PIN, PTP, RON
Smilacina racemosa	False solomon's seal	PTP, RON, PIN
Smilax herbacea	Carrion flower	PTP, RON
Smilax rotundifolia	Common greenbriar	RON
Smilax tamnoides	Bristly greenbriar	PTP, RON
Solanum nigrum	Black nightshade	PIN
Solidago canadensis	Canada goldenrod	PIN, RON
Streptopus sp.	Twisted stalk	PTP

Symphoricarpos albus	Snowberry	PIN, PTP, RON
Taraxacum officinale	Common dandelion	PIN, PTP, RON
Trifolium pratense	Red clover	RON
Urtica sp.	Nettle	RON
Uvularia perfoliata	Perfoliate bellwort	PIN, PTP, RON
Vaccinium sp. *(angustifolium?)*	Blueberry	PIN, PTP, RON
Viburnum sp.	Arrowwood	PIN, PTP, RON
Vicia cracca	Cow vetch	
Vinca minor	Periwinkle	PIN, RON
Viola sp.	Violet	PIN, PTP, RON
Vitis sp.	Grape	PIN, PTP, RON
Unkowns (Many have now been identified, but the list is not yet updated)		
Now know to be *Commandra* sp.	Unknown herb 2	PIN
	Unknown herb (1)	PIN
	Unknown shrub	PIN
Ceanothus spp?	Unknown (shrub sample)	PIN
	Unknown blueberry like	PIN
	Unknown shrub 5	PIN
	Unknown 5	PTP
	Unknown shrub	PTP
	Unknown (herb) 11	PTP
	Unknown(herb) 12	PTP
	Vine leaf divided, 3 leaflets	PTP
Celastrus scandens	Vine single leaf entire	PTP
	Grass 3	PTP
	Grass sample	PTP
	Herb1	PTP
	Unk sample #5	RON
	Unknown	RON
	Unknown # 1	RON
	Unknown # alternate	RON
	Unknown hairy	RON
	Unknown herb	RON
	Unknown herb 3	RON
	Grass #1	RON
	Grass #2	RON
	Grass #3	RON
	grass small	RON
Celastrus scandens	Vine 1	RON
Celastrus scandens	Vine 2	RON

Appendix II: Latin and common names, DCA species codes, and origin (native [N] or exotic [E]) of all species found in cottage sites in Point Pelée National Park 1994/95 and 2000 (VC = Visitor Centre; GA = Gary; RB = Ribble; BR = Bruner).

Species		**Origin**	**Site(s) of occurrence**		**Label used in DCA analysis**
Latin name	**Common name**		**1994/1995**	**2000**	
Acer saccharum	Sugar maple	N	VC	VC	ACERSACC
Alliaria petiolata	Garlic mustard	E	VC,RB,BR	VC,RB,BR	ALLIPETI
Allium vineale	Field garlic	E	VC	BR	ALLIVINE
Ambrosia artemesiifolia	Common ragweed	N	GA,RB	GA	AMBRARTE
Asclepias syriaca	Common milkweed	N	BR		ASCLSYRI
Aster spp	aster species	N	VC,GA,RB,BR	GA,BR	ASTERSPP
Berteroa incana	Hoary alyssum	E	GA		BERTINCA
Campanula americana	Tall bellflower	N	VC	VC,BR	CAMPAMER
Capsella bursa-pastoris	Shepherd's purse	E	GA		CAPSBURS
Cardamine spp	cress species	N	VC,GA,RB,BR	RB	CARDASPP
Carex spp	sedge species	N	VC,GA,RB,BR	VC,GA,RB,BR	CAREXSPP
Celtis spp	Hackberry	N	VC,GA,RB,BR	VC	CELTISPP
Cerastium arvense	Field chickweed	N	GA		CERAARVE
Cerastium vulgatum	Mouse-ear chickweed	E	GA		CERAVULG
Circaea quadrisulcata	Enchanter's nightshade	N		VC,RB	CIRCQUAD
Commelina communis	Asiatic dayflower	E	GA		COMMCOMM
Convallaria majalis	Lily-of-the-valley	E	BR	BR	CONVMAJA
Cornus drummondii	Rough dogwood	N	VC,GA,RB		CORNDRUM
Corydalis flavula	Yellow corydalis	N		VC	CORYFLAV
Daucus carota	Wild carrot	E	VC		DAUCCARO
Equisetum arvense	Common horsetail	N	GA	GA	EQUIARVE
Erigeron annuus	Daisy fleabane	N	BR		ERIGANNU
Erigeron canadensis	Horseweed	N	GA		ERIGCANA
Erigeron pulchellus	Robin's plantain	N	VC,GA,BR		ERICPULC
Euphorbia maculata	Eyebane	N	GA		EUPHMACU
Fragaria vesca	Wood strawberry	N		BR	FRAGVESC
Fraxinus Americana	White ash	N		GA	FRAXAMER
Galium aparine	Cleavers	N	VC,GA,RB,BR	VC,GA,RB,BR	GALIAPAR
Geranium maculatum	Wild geranium	N	GA		GERAMACU
Geranium robertianum	Herb robert	N	RB	VC,RB,BR	GERAROBE
Geum canadense	White avens	N	GA,BR	VC,GA,RB,BR	GEUMCANA
Geum laciniatum	Rough avens	N	VC,GA,RB,BR	RB	GEUMLACI
Geum macrophyllum	Large-leaved avens	N		VC,BR	GEUMMACR
Glechoma hederacea	Ground ivy	E	GA,RB	VC	GLECHEDE
Graminae (family)	grass species	N/E	VC,GA,RB,BR	VC,GA,RB	GRASSSPP
Hedera helix	English ivy	E	VC		HEDEHELI
Humulus lupulus	Common hop	E		GA	HUMULUPU
Juglans nigra	Black walnut	N	BR		JUGLNIGR
Juniperus virginiana	Eastern redcedar	N	RB		JUNIVIRG
Lamium amplexicaule	Henbit	E	GA		LAMIAMPL
Lamium purpureum	Purple dead nettle	E	BR		LAMIPURP

Leonurus cardiaca	Motherwort	E	GA,BR		LEONCARD
Lonicera spp	Honeysuckle species	N		VC,RB,BR	LONICSPP
Lychnis alba	White campion	E	GA	GA,BR	LYCHALBA
Maianthemum canadense	Canada mayflower	N	VC		MAIACANA
Medicago lupulina	Black medic	E	GA,RB		MEDILUPU
Melilotus alba	White sweet clover	E	RB		MELIALBA
Melilotus officinalis	Yellow sweet clover	E	GA,RB		MELIOFFI
Menispermum canadense	Moonseed	N	BR		MENICANA
Narcissus pseudo-narcissus	Daffodil	E	VC		NARCPSEU
Ornithogalum umbellatum	Star of Bethlehem	E	VC	VC	ORNIUMBE
Osmorhiza claytoni	Sweet cicely	N	VC,BR	VC,RB,BR	OSMOCLAY
Osmorhiza longistylis	Aniseroot	N	VC,RB,BR		OSMOLONG
Oxalis stricta	Wood sorrel	N	VC,GA,BR	BR	OXALSTRI
Parthenocissus quinquefolia	Virginia creeper	N	VC	VC	PARTQUIN
Phlox paniculata	Garden phlox	E	VC		PHLOPANI
Phryma leptostachya	Lopseed	N	VC,RB		PHRYLEPT
Physalis heterophylla	Clammy ground cherry	N	GA		PHYSHETE
Plantago lanceolata	Narrow-leaved plantain	E	GA		PLANLANC
Plantago major	Common plantain	E	GA		PLANMAJO
Podophyllum peltatum	Mayapple	N	VC		PODOPELT
Polygonatum biflorum	Smooth solomon's seal	N	VC,RB,BR	BR	POLYBIFL
Polygonatum canaliculatum	Great solomon's seal	N	RB,BR		POLYCANA
Polygonum scandens	Climbing false buckwheat	N	VC,BR		POLYSCAN
Potentilla norvegica	Rough cinquefoil	N		GA	POTENORV
Potentilla recta	Rough-fruited cinquefoil	E	GA	GA	POTERECT
Prunus serotina	Black cherry	N	VC,RB,BR		PRUNSERO
Prunus virginiana	Choke cherry	N	VC	BR	PRUNVIRG
Pteridium aquilinum	Bracken fern	N	VC	VC	PTERAQUI
Quercus rubra	Red oak	N	VC		QUERRUBR
Quercus velutina	Black oak	N	VC		QUERVELU
Ranunculus abortivus	Small-flowered crowfoot	N	VC		RANUABOR
Rhus radicans	Poison ivy	N	VC,GA,BR	VC,BR	RHUSRADI
Rhus typhina	Staghorn sumac	N	VC	VC	RHUSTYPH
Ribes cynosbati	Prickly gooseberry	N	RB		RIBECYNO
Rosa blanda	Smooth rose	N	GA		ROSABLAN
Rubus occidentalis	Thimbleberry	N	RB,BR	BR	RUBUOCCI
Rumex crispus	Curled dock	E	GA		RUMECRIS
Sanicula marilandica	Black snakeroot	N		GA	SANIMARI
Saponaria officinalis	Bouncing bet	E	RB,BR	VC,RB,BR	SAPOOFFI
Scilla spp	Scilla species	E	VC		SCILLASP
Scutellaria lateriflora	Mad-dog skullcap	N		VC	SCUTLATE
Scutellaria parvula	Small skullcap	N		BR	SCUTPARV
Setaria glauca	Yellow foxtail	E	GA		SETAGLAU

Silene noctiflora	Night flowering catchfly	E	BR		SILENOCT
Smilacina stellata	Star-flowered solomon's seal	N	VC	VC,BR	SMILSTEL
Smilax herbacea	Carrion flower	N	VC,BR	VC,BR	SMILHERB
Smilax tamnoides	Bristly greenbriar	N	VC	VC	SMILTAMN
Solanum nigrum	Black nightshade	E		VC,RB,BR	SOLANIGR
Solidago altissima	Tall goldenrod	N	VC,GA,RB		SOLIALTI
Solidago canadensis	Canada goldenrod	N	VC,GA,BR	GA,RB	SOLICANA
Stellaria alsine	Bog chickweed	E		VC,RB,BR	STELALSI
Stellaria media	Common chickweed	E	VC,GA	VC	STELMEDI
Syringa vulgaris	Common lilac	E	RB,BR		SYRIVULG
Symphoricarpos albus	Snowberry	N		VC	SYMPALBU
Taraxacum officinale	Common dandelion	E	GA,RB,BR	RB,BR	TARAOFFI
Trifolium agrarium	Hop clover	E		GA	TRIFAGRA
Trifolium dubium	Least hop clover	E	GA		TRIFDUBI
Trifolium repens	White clover	E	GA		TRIFREPE
--	Unknown 94sp1	E	VC	VC	UNK94SP1
--	Unknown 00sp1			VC	UNK00SP1
--	Unknown 00sp3			VC	UNK00SP3
--	Unknown 00sp4			VC	UNK00SP4
--	Unknown 00sp5			VC	UNK00SP5
Urtica gracilis	Slender nettle	N	GA,RB		URTIGRAC
Verbascum thaspus	Common mullein	E	GA		VERBTHAS
Verbena urticifolia	White vervain	N	RB		VERBURTI
Veronica arvensis	Corn speedwell	E	GA		VEROARVE
Viola sororia	Wooly blue violet	N	VC,RB,BR	RB,BR	VIOLSORO
Vitis aestivalis	Summer grape	N		RB	VITIAEST
Vitis labrusca	Fox grape	E		VC,RB,BR	VITILABR
Vitis riparia	Riverbank grape	N	GA,RB		VITIRIPA

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