Interactions between deer and vegetation in southern Ontario, Canada:
Monitoring and restoration of overgrazed plant communities in Pinery and Rondeau Provincial Parks

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Executive Summary

One of the main goals of this report was to lodge a single record of our numerous research activities on deer-plant interactions in southern Ontario. Table 1 summarizes the project's components and illustrates its wide scope. Not all of the results from these studies are presented in this report; some results are in other reports, while some data, specifically that on stand composition, soil seed bank composition, and woody browse availability, still await analysis. With the large database that we have amassed, we are now well placed to accurately monitor and assess changes in plant communities as vegetation recovers following the deer herd reduction in Rondeau and to place the ongoing degradation of grazed vegetation at Pinery into both a spatial and historical context.

In spring 1994 it was clear that there was more herbaceous vegetation at Rondeau than at any time since 1991. This rapid recovery in deer grazed areas was expected based on the results of exclosure studies. Preliminary results from our studies of plant community composition showed that the plant community at Rondeau changed following protection from deer grazing in 1991 and 1978 exclosures. In 1994, both the grazed and ungrazed sites at Rondeau were distinguished from the Pinery sites in having a higher percent cover and a greater abundance of herbaceous species, typical of a mature, undisturbed Carolinian forest (e.g. *Viola* spp.). However, in 1992 these same Rondeau sites were distinguishable from other less heavily grazed location in southern Ontario because they had a higher percent cover of grazing tolerant species (e.g. *Aster* spp.). We do not yet know whether the plant community will return to its condition before disturbance by deer grazing or whether the "recovered" community will be fundamentally different - only time will tell. In 1995 we will be analyzing data sets from Rondeau for 1991, 1992, 1994 and 1995 to determine how the plant community has changed with time.

We had success with the use of plant species as indicators of overall vegetation recovery following grazing, although only two of the five species which we assessed were suitable. In addition to *Trillium grandiflorum* (Koh et al., 1995), *Circaea quadrisulcata* and *Polygonatum biflorum* were good indicators of grazing pressure and habitat protection at Rondeau. Plant sizes observed throughout the park were determined more by deer grazing, which imposes homogeneity across grazed sites, than by habitat variation (e.g. soil type). The three other candidates for indicator species did not respond to release from deer grazing pressure as well, and their heights appeared to be related more to other factors than deer grazing. In

1995 appropriate indicator species will be determined for Pinery. While some rare plants such as Showy Orchis flowered for the first time in years in Rondeau, in general we found that effective monitoring of the recovery of rare species within the park required greater effort than was possible from two or three individuals doing sporadic searches. Due to the many negative results (failure to find species) we must develop a stringent protocol for quantifying search effort. As a consequence, S. Koh, D. Bazely, and A. Woodliffe (OMNR) will be designing a protocol which accounts for search effort and will make use of the potential volunteer base from Rondeau's visitors.

Exotic and invasive plant species are of concern in any habitat which has been released from strong grazing pressure. It appears unlikely that the lower grazing pressure at Rondeau will result in as wide a distribution of weedy, invasive species as at Point Pelée National Park (e.g. *Alliaria officinalis*) because of the robust seedbank which contains many native species (Koh & Bazely, 1994). The greater crown cover at Rondeau (Koh, pers. comm.), in contrast to Point Pelée which is more open, will not provide as suitable a habitat for these weedy species with respect to light availability. However, in disturbed areas within Rondeau (e.g. along roadsides) some weedy species appear to be spreading. Treatment and monitoring programs initiated in 1994 will continue for *A. officinalis* in 1995. *Berberis thunbergii* (woody exotic) may have spread throughout Rondeau due to their thorns which defend them against grazing. This species may be less competitive against native shrubs now that grazing pressure has been reduced. We recommend that treatment programs be continued, and monitoring programs be established for this species.

Since a herd reduction has not taken place at Pinery and has only recently occurred at Rondeau, it is vital to have a comprehensive baseline dataset against which to compare continuing habitat degradation or recovery. Such a database is in the process of being created for the woody stand structure and woody-browse, and herbaceous plant communities in both Pinery and Rondeau. Each year, data collected from the parks over the duration of the project can be compared against this baseline to monitor changes over time and grazing pressure. A report after the 1995 field season will provide the first indication of what changes can be expected in the long-term recovery process.

1. Introduction

Herbivores play an important role in determining the species diversity of plant communities by influencing the relative abundance and distribution of plant species (Crawley, 1983; Watkinson, 1988; Grace & Tilman, 1990). Selective consumption by herbivores among co-occuring plants (Brown & Stuth, 1993) and/or the different abilities of these plants to respond to grazing pressure (McNaughton, 1979; Louda, 1984; Rockwood & Lobstein, 1994) often dictate dominance hierarchies. Plants which are weak competitors in the absence of herbivores can obtain a competitive advantage over dominant species under certain grazing regimes (Alexander & Thompson, 1982; Bergelson, 1990; Clay et al., 1993). Many plant communities undergo long-term changes after being heavily browsed or grazed (Brandner et al., 1990; Stuart-Hill, 1992; Anderson & Radford, 1994; Shimoda et al, 1994). Consequently, managers of natural areas need to monitor the outcome of herbivory in order to conserve and restore threatened habitats.

In the Carolinian Zone of southern Ontario's forests, herbivory by white-tailed deer (*Odocoileus virginianus*) has had a localized but major impact on the structure and composition of plant communities. This is of great concern since this forest zone contains 70% of the province's rare plant species (Varga & Allen, 1990). In the last decade, high deer densities in some "premiere" Carolinian sites (e.g. Rondeau and Pinery Provincial Parks, Long Point National Wildlife Area, and Point Pelée National Park) have resulted in increased awareness of the potential loss of rare plant species. In some sites, reduction of deer populations has been undertaken to mitigate the problem (e.g. Rondeau Provincial Park and Long Point National Wildlife Area, and Point Pelée National Park). In order to assess the extent of deer overgrazing, studies have been initiated to determine the effect of deer grazing on herbaceous and woody plant communities. Ultimately, these studies will determine the level of grazing pressure which would allow the recovery of these habitats.

In 1991, Koh (1991) examined herbaceous plant communities at Rondeau Provincial Park in exclosures built in 1978 and 1991 in relation to deer-grazed areas. Plant communities in 1991 exclosures (built in dry, wet and mesic habitats in February 1991) showed an increase in percent cover compared to the grazed areas during one growing season. There were no changes in species diversity between the grazed and exclosed plots (Koh, 1991). The plant community

composition of the 1978 exclosures was significantly different from adjacent heavily grazed areas. *Arisaema triphyllum*, *Podophyllum peltatum*, and *Trillium* spp. were abundant in these older exclosures compared to adjacent grazed areas. This study suggested that perennials which experienced reduced abundance after intense grazing were able to recover once this stress was removed.

As a component of a larger study carried out in 1992, which looked at 11 locations in southern Ontario, exposed to a range of deer-grazing pressure (Figure 1; Tables 1 & 2), Koh & Bazely (1992) compared the herbaceous plant community composition of Hillman Sand Hills and Point Pelée National Park (two nearby locations). In January 1991, herd reductions were carried out at Point Pelée reducing the deer population from an estimated 36 to 7 deer/km^2 (Landplan, 1991). Deer population density at Hillman Sand Hills had been significantly lower than Point Pelée. The common plant species differed between the two sites. Spring ephemerals such as *Arisaema triphyllum* , *Podophyllum peltatum* , and *Trillium grandiflorum* occurred exclusively at Hillman while weedy invasive species such as *Alliaria officinalis* , *Galium triflorum*, *Solidago rugosa*, *Stellaria media*, and grazing tolerant graminoids were either more abundant or had higher maximum percent cover at Point Pelée. In a seedbank study of Point Pelée National Park, Hillman Sandhills and Rondeau Provincial Park which started in 1992, Koh & Bazely (1994) found that sites with histories of high grazing pressure had a higher proportion of seedlings of non-native origin in comparison to less grazed sites. Both studies (Koh & Bazely, 1992; 1994) emphasized the need to monitor invasive and exotic species in habitats recovering from high grazing pressure following deer herd reductions since deer grazing tended to reduce vegetation cover, providing potential for colonization by weedy species.

In an effort to provide managers with an index of deer grazing pressure, Koh, Bazely & Voigt (1994) looked at the effect of deer grazing on the height of *Trillium grandiflorum* over 3 years in 11 forested areas in southern Ontario (Figure 1; Table 1). *T. grandiflorum* is a long lived perennial distributed throughout southern Ontario. The mean of the maximum plant heights measured from individual plants over a growing season at a site was negatively correlated with the average deer population density during the previous six years. Plants in more heavily grazed sites were significantly younger than those in less grazed sites. In addition, the percentage of plants flowering in a site was positively correlated with mean plant height and negatively correlated with average deer density. Grazing was

associated with a reduction in plant height in subsequent years due to a loss of photosynthetic capacity.

White-tailed deer have also had a negative impact on woody plant communities in a number of Carolinian sites; severe browsing over many years has prevented regeneration in that seedlings of many species fail to grow beyond sapling height (Yaraskavitch, 1983; McCullough & Robinson, 1988; Landplan, 1990; 1991). Bazely & Koh (1994) found that the majority of shrubs at Point Pelée National Park fell into the smallest size class (0-1 cm stem diameter), whereas the shrubs at Hillman Sandhills and Rondeau Provincial Park had a more even distribution of size classes (0-8 cm stem diameter). They suggested that the large number of shrubs within the 0-1 cm size class at Point Pelée was the result of release from deer grazing pressure following a recent herd reduction in 1990 and 1991.

The purpose of this report is to describe the foundation of a five year project funded by the Southern Region Science & Technology Unit of the Ontario Ministry of Natural Resources. The project objective is to monitor and manage the effects of deer herbivory on the plant communities of Rondeau and Pinery Provincial Parks. This project builds on previous studies carried out by Bazely, Koh, and Voigt from 1991 to 1993 in both these and other locations (Table 2). While the current project is centered in Rondeau and Pinery, it is designed to further a general understanding of the interaction between deer and plants in order to improve the management of Carolinian forest ecosystems throughout southern Ontario. Consequently, some studies will be conducted outside the Parks for comparative purposes.

This project is also designed to meet the specific management needs of Rondeau and Pinery Provincial Parks. At Rondeau Provincial Park, the study will 1) provide the foundation for a long-term program to monitor and document the response of vegetation to the deer with special reference to the herd reduction carried out in the winter 1993/94, 2) determine whether the density of deer is at a level which will allow habitat recovery, and 3) establish whether certain species require restoration (due to rarity and/or deer selectivity) or control (e.g. exotics such as Japanese Barberry (*Berberis thunbergii*) and Garlic Mustard (*Alliaria officinalis*). At Pinery Provincial Park, the study will 1) document the effects of current herd levels on herbaceous and woody plants, 2) estimate the density of deer that will allow recovery of the forest habitat, and 3) establish a long-term program to monitor the vegetation before and after a herd reduction.

This report examines the following components of the 1994 research season at Rondeau and Pinery Provincial Parks:

1) Variation in plant community structure at 11 locations across southern Ontario in 1992 and representative habitat types at Rondeau and Pinery Provincial Parks in 1994.

2) The results of a survey of rare plant species at Rondeau Provincial Park in 1994.

3) The usefulness of *Arisaema triphyllum, Circaea quadrisulcata* , *Maianthemum canadense*, *Polygonatum biflorum*, and *Rhus radicans* as indicators of grazing pressure in Rondeau in 1994.

4) A series of experiments initiated in 1994 to determine a means of controlling Garlic Mustard and Japanese Barberry in Rondeau Provincial Park.

5) A protocol for investigating the dispersal and spread of Garlic Mustard at Rondeau.

6) A description of the methods used to monitor the structure and composition of woody communities across Southern Ontario, and the methods used to determine the biomass of woody browse available to the deer in Rondeau and Pinery Provincial Parks.

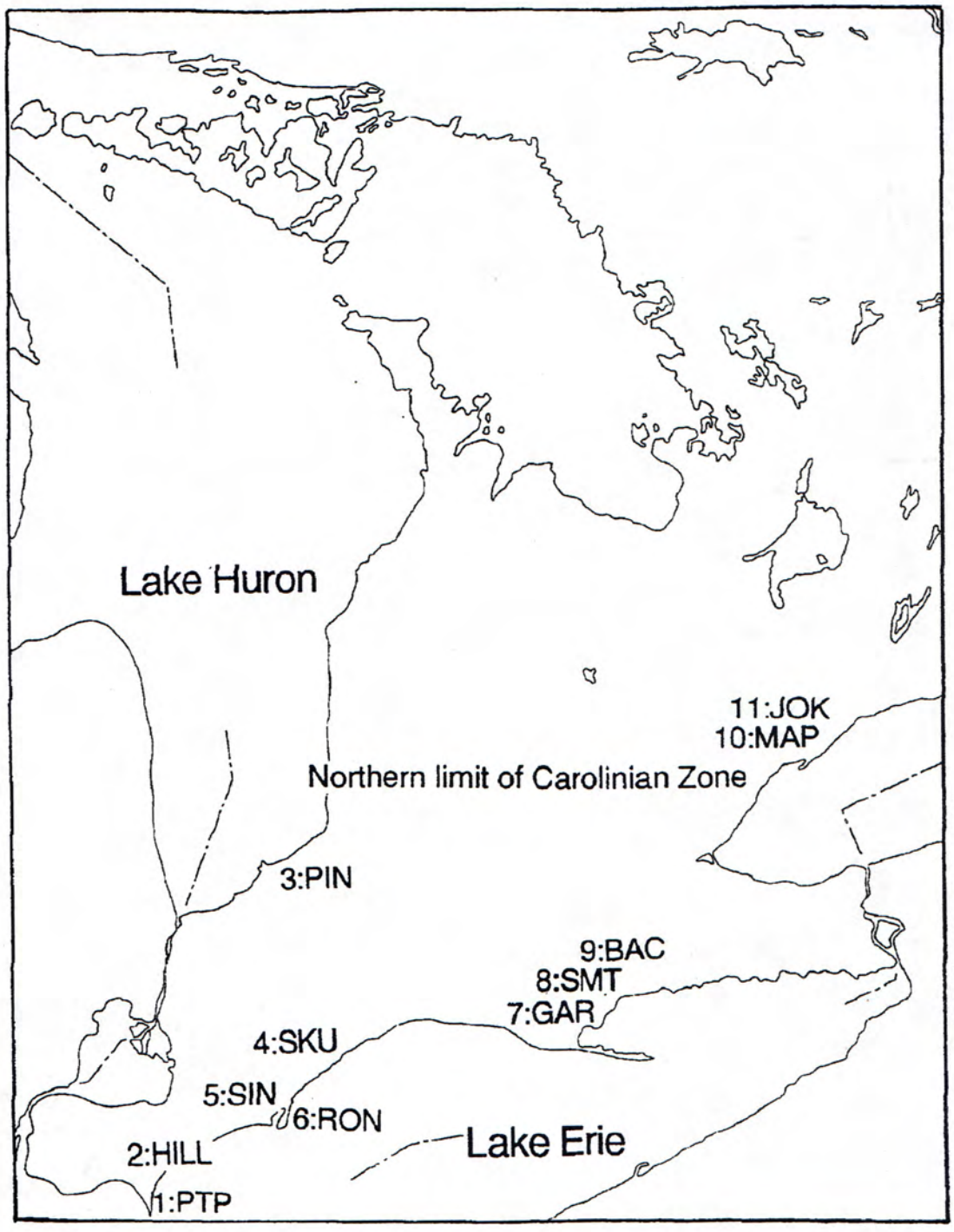


Figure 1. Location of study sites in southern Ontario used by S. Koh, D. Bazely, and D. Voigt from 1991-1994.
1) Point Pelée National Park, 2) Hillman Sandhills, 3) Pinery Provincial Park, 4) Skunk's Misery, 5) Sinclair's Bush, 6) Rondeau Provincial Park, 7) Gartshore-Moulton Tract, 8) Dan-Smith Tract, 9) Backus Woods, 10) Maple, 11) Joker's Hill

Table 1. Study site locations, forest cover of parks and adjacent areas of non-park locations, and their past and present deer densities.

No.	Location	Site	Latitude N/ Longitude W	% of Area Forested†	Present Deer Density (no. deer km^{-2}) 1991-1993	Past Deer Density (no. deer km^{-2}) see notes for period
1	Rondeau Provincial Park		42° 17' / 81° 53'	-	-	-
	-grazed, forested areas	RON		90% (11 km^2)	50-54	30-45[a]
	-deer exclosure Bennett St.	BEX		-	0	5-50[b]
	-deer exclosure Gardiner St.	GEX		-	0	5-50[b]
	-forty 2 x 2 m deer exclosures erected 1991	NEX		-	0	30-45[a]
2	Point Pelée National Park	PTP	41° 57' / 82° 31'	90% (4 km^2)	11	6-40[c]
3	Hillman Sandhills	HIL	42° 05' / 82° 31'	3% WMU no. 94	10-11	not available[d]
4	Sinclair's Bush	SIN	42° 21' / 81° 56'	9% WMU no. 93	14	6[e]
5	Skunk's Misery	SKU	42° 38' / 81° 49'	16% WMU no. 92	14	6[e]
6	Pinery Provincial Park	PIN	43° 15' / 81° 51'	80% (20 km^2)	41	15-26[f]
7	Gartshore/Moulton Tract	GAR	42° 37' / 80° 32'	20% WMU no. 90	9	6[e]
8	Backus Woods	BAC	42° 38' / 80° 28'	20% WMU no. 90	9	6[e]
9	Maple	MAP	43° 55' / 79° 29'	18% WMU no. 78	7-8	7[g]
10	Joker's Hill	JOK	44° 01' / 79° 31'	18% WMU no. 78	7-8	7[g]
11	Danijlevitch-Smith	DAN	42° 46' / 80° 24'	20% WMU no. 90	9	6[e]

†All sites were forest but non-park sites were surrounded by farmland with % forest given for Wildlife Management Units (WMUs) where these sites were located. See Figure 1. For parks, actual area of deer range (km^2) also given.

[a]1982-1989

[b]annual estimates prior to exclosing in 1978: 1976: 39 deer km^{-2}; 1970: 12; 1960: 11; 1955: 18; 1945: 5; 1935: 50; 1928: 14; 1918: 45.

[c]1988-1990, early 1970s estimated at 6-7 deer km^{-2}

[d]1950s-1960s cattle grazed

[e]1987

[f]1980-1989

[g]1989-1990

Table 2. Studies carried out by S. Koh, D. Bazely, and D. Voigt at 11 locations across southern Ontario from 1991-1994.

Sites	1991	1992	1993	1994
Rondeau			*	
a) d, m, w	H, D	H, D, S, RT, B	H, S, W	H, W, Wb, I, G/J, G
b) Bennett	H, D	H, D, S, B	H, S, W	-
c) Gardiner	H, D	H, D, S, B	H, S, W	-
Point Pelée	*	H, Dt, S, B	H, S, W	-
Pinery	-	H, Dt, S, B	S, W	H, W, Wb
Hillman Sandhill	-	H, Dt, S, B	H, S, W	-
Sinclair's Bush	-	H, Dt, S, RT, B	S, W	-
Skunk's Misery	-	H, Dt, S, B	S, W	-
Gart-Moult	-	H, Dt, S, B	S, W	-
Backus Woods	-	H, Dt, S	S, W	-
Joker's Hill	-	H, Dt, S, B	S, W	SIM
Maple	-	H, Dt, S, B	S, W	-
Danijlevitch-Smith	-	Dt	-	-

*herd reduction
d-dry habitat; m-mesic habitat; w-wet habitat
H-herbaceous cover (paired in grazed and exclosed plots); D-plant demography for *Trillium, Arisaema, Viola*;
Dt-plant demography for *Trillium*; S-seedbank; RT-reciprocal transplant experiments with *Viola*;
B-collection of above-ground biomass; W-survey of woody vegetation; Wb-woody browse;
I-indicator species for deer grazing effects; G/J-control of garlic mustard and Japanese barberry;
G-spread and dispersal of garlic mustard; SIM-simulated herbivory experiment with *Trillium.*

2. Herbaceous Plant Communities of Southern Ontario with Particular Reference to Pinery and Rondeau Provincial Parks

PURPOSE

Using principal components analysis as an exploratory tool, we examined variation in plant community structure in 11 locations across southern Ontario with data collected in 1992 by S. Koh, D. Bazely, and D. Voigt. The same analysis was used to look at data collected from herbaceous plant communities in representative habitat types at Rondeau and Pinery Provincial Parks collected in 1994. These analyses provided an opportunity to examine plant community responses following a herd reduction at Rondeau, and set a baseline for plant communities at Pinery before any future herd reductions. The 1992 data allowed us to compare plant communities at Rondeau and Pinery with other sites in southern Ontario which have undergone a range of grazing pressure.

DATES & LOCATIONS

A) May-August 1992: Rondeau Provincial Park, Point Pelée National Park, Hillman Sandhills, Sinclair's Bush, Skunk's Misery, Pinery Provincial Park, Gartshore-Moulton Tract, Backus Woods, Maple, and Joker's Hill.
B) July-August 1994: Rondeau and Pinery Provincial Parks.

METHODS

A) Plant Community Composition in 1992

The frequency (i.e. number of individuals) and percent cover of each herbaceous plant species (including the seedlings of woody species) were scored in exclosures and grazed plots at the following 10 locations in Southern Ontario (Figure 1; Tables 1 & 2): Rondeau Provincial Park, Point Pelée National Park, Hillman Sandhills, Sinclair's Bush, Skunk's Misery, Pinery Provincial Park, Gartshore-Moulton Tract, Backus Woods, Maple, and Joker's Hill.

At Rondeau Provincial Park, Koh (1991) established three permanent north-south transects (1000 m in length) in each of the park's three major habitat types (dry, mesic and wet) in 1991 (Figure 2). Ten sites were randomly chosen along the three transects in each habitat to give a total of 30 sites. At each site, a set of plots was established: one 1 m x 1 m grazed plot and two 2 m x 2 m exclosures located 5 m north and south of the grazed plot. Within these exclosures, a 1 m x 1 m quadrat was placed in the furthest corner from the door and 10 cm in from the exclosure

fence. Inside two exclosures (Bennett and Gardiner) built in 1978, 10 quadrats (1 m x 1 m) were laid out at 6 m intervals along a transect running parallel to and 5 m from the exclosure fence. Corresponding paired grazed plots were located 5 m outside of these large exclosures. All grazed and exclosed quadrats were scored seven times in 1992 within 2 days of the following dates: May 4, May 20, June 4, June 23, July 10, August 3, August 26.

In the first week of March 1992, 10 sites were chosen in each of the remaining 9 locations which had varying deer densities. These sites were located at random along two to six transects which varied from 40-1200 m long; the number and length of transects depended on the shape and size of each location. At Maple and Joker's Hill, sites were randomly chosen from a grid coordinate system. At each site, a 1 m x 1 m exclosure was built, and an adjacent 1 m x 1 m grazed plot was laid out 3 m from the exclosure on a random compass bearing. The dominant species that characterized these sites included: *Quercus alba*,*Quercus velutina*, and trees typical of the flood plain forests at Pinery (Bakowsky, 1990); *Acer* spp. and *Quercus* spp. at Hillman and Sinclair's Bush; *Acer saccharum* at Joker's Hill and Maple; *Acer rubrum* and *Fagus grandifolia* at Backus woods; *Acer rubrum*,*Fagus grandiflorum*, *Fraxinus* spp., and *Quercus* spp. at Skunk's Misery; *Celtis occidentalis* at Point Pelée; and *Acer rubrum* and *Fagus grandifolia* at Gartshore-Moulton. The grazed and exclosed plots from these locations were examined four to five times during the growing season from May to August 1992.

In 1994, a database was established in which the 1992 data were entered in their entirety. For this report, a preliminary principal components analysis was run with a reduced database. For all the sites at the 10 locations, we extracted the maximum value recorded in 1992 for the frequency and percent cover in each quadrat for each species. The maximum values were used since different species emerge and are present for different amounts of time during the growing season. At Rondeau, maximum values were summed as follows prior to the analysis: quadrats were pooled into groups of ten so that habitats (dry, mesic, and wet) were kept separate and within habitats, groups of north and south exclosures and grazed quadrats were kept separate (i.e. each habitat had the data for three groups of ten quadrats pooled). The ten maximum values for each of the exclosed and grazed sites at Gardiner, Bennett and the remaining locations were also pooled for each species. If a species appeared in at least 50% of the 20 plots (grazed and exclosed plots combined) in a location or habitat type (in Rondeau) then that species was included in a principal components analysis of plant community

structure; a total of 30 species were chosen using this criterion. Separate principal components analyses were run for each of the frequency and percent cover datasets. Frequency measurements were only available for 26 of the 30 species (Table 3).

B) Plant Community Composition in 1994

In July and the first week of August, frequency and percent cover of plant species were scored in 1 m x 1 m quadrats in exclosures and grazed plots at Rondeau and Pinery. At Rondeau, only the sites located in dry, wet, and mesic habitats were scored. In June 1994, one of the 2 m x 2 m exclosures at each site was randomly selected and moved an additional 10 m north or south of its location, depending on whether it was originally north or south of the grazed plot. The relocated exclosure was at a grazed site relative to the exclosure remaining in its original position. At Pinery, 10 sites were randomly selected in each of the park's six representative habitat types: black oak savannah, black and white oak savannah, cedar savannah, conifer-oak forest, flood plain forest, and oak forest (Figure 3; Bakowsky,1990). Sites within a habitat were separated by at least 150 m. At each of these sites, a 2 m x 2 m exclosure was built, and a corresponding grazed plot was laid out 3 m from the exclosure on a random compass bearing.

For each habitat type at Rondeau and Pinery, we summed the frequency or percent cover measurements for each species within each group of 10 exclosed and 10 grazed plots. If a species appeared in at least 40% of the 20 plots (grazed and exclosed plots combined) in a habitat type, it was included in a principal components analysis of the plant community structure of the two parks; a total of 34 species were chosen using this criterion. The criterion of 50% appearance used with the 1992 dataset was lowered to 40% in the analysis of the 1994 dataset to include several species of interest. A separate principal components analysis was performed for each of the frequency and percent cover datasets. Frequency measurements were only available for 32 of the 34 species (Table 4).

Due to intense grazing pressure some plants in grazed plots could only be reliably identified to genus. Since grasses rarely flowered, all graminoid species were lumped into a single category. In 1992, *Galium* spp. were classified by leaf number which resulted in several species being grouped in the same category while in 1994 they were classified to species. Thus in the principal components analyses, 1992 and 1994 analyses treat *Galium* differently.

RESULTS

The principal component analyses for this report were used in an exploratory manner to determine trends in the plant community structure among several locations within the same year. At this point in the study we were setting up a "baseline" for future analyses in which changes in plant communities over time will be analyzed. The use of the term "high loading" in principal component analysis indicates that a variable has a greater weight or importance in determining the value of a principal component. Differences in the sign (i.e. negative or positive) of variables within a principal component indicate that these variables are negatively correlated. As a result of variables having different signs, the value given to a principal component can be negative or positive. In this report, the variables used to determine the value of a principal component were plant species occurring in different locations, and a principal component score was calculated for each location/habitat type based on species loadings.

Further analyses (e.g. DECORANA: Detrended Correspondence Analysis) of this computerized data set will be included in S. Koh's Ph.D. thesis.

A) Plant Community Composition in 1992

For the 1992 data set, the first three principal components in the analyses of the percent cover and frequency data explained over 50% of the total variation (Table 3). After a Varimax Rotation of these three components, in order to simplify their interpretation, a plot was made of the first and second, second and third, and first and third components (Figures 4-6).

For the percent cover data, the loading on the first principal component was high for groups such as *Aster* spp., *Aquilegia canadensis* (columbine), *Galium* spp., and graminoids (Table 3a). This component showed a gradient for grazing pressure since the above species are more grazing tolerant (Koh, 1991). Highly grazed sites such as those found at Rondeau before the 1993 herd reduction tended to have positive values whereas less intensively grazed areas such as Sinclair's Bush or the 1978 exclosures at Rondeau (Gardiner and Bennett) had negative values (Figures 4 & 6). The second principal component showed a high loading for species such as *Alliaria officinalis*, *Osmorhiza claytoni*, *and Stellaria media* ; these are species which tend to form dense stands and, with the exception of *O. claytoni*, can be invasive (Table 3a). The grazed and exclosed sites at Point Pelée were separated from other sites along this component (Figures 4-5). Koh and Bazely (1992) found that Point Pelée was dominated by invasive weedy species compared to other sites, and speculated that this may be correlated with

the herd reduction of 1990, following which these plants spread into an overgrazed open habitat. The third component showed a high positive loading for *Arisaema triphyllum*, *Viola* spp., and *Dentaria* spp., and a high negative loading for *Acer* spp. and *Claytonia* spp. (Table 3a). High positive values (e.g. Bennett exclosure) occurred in sites with an understorey typical of a mature, undisturbed Carolinian forest. The dominance of *Acer* spp. at sites such as Maple and Joker's Hill which were the most northerly sites explained the large negative values for these sites along the third component (Figures 5-6).

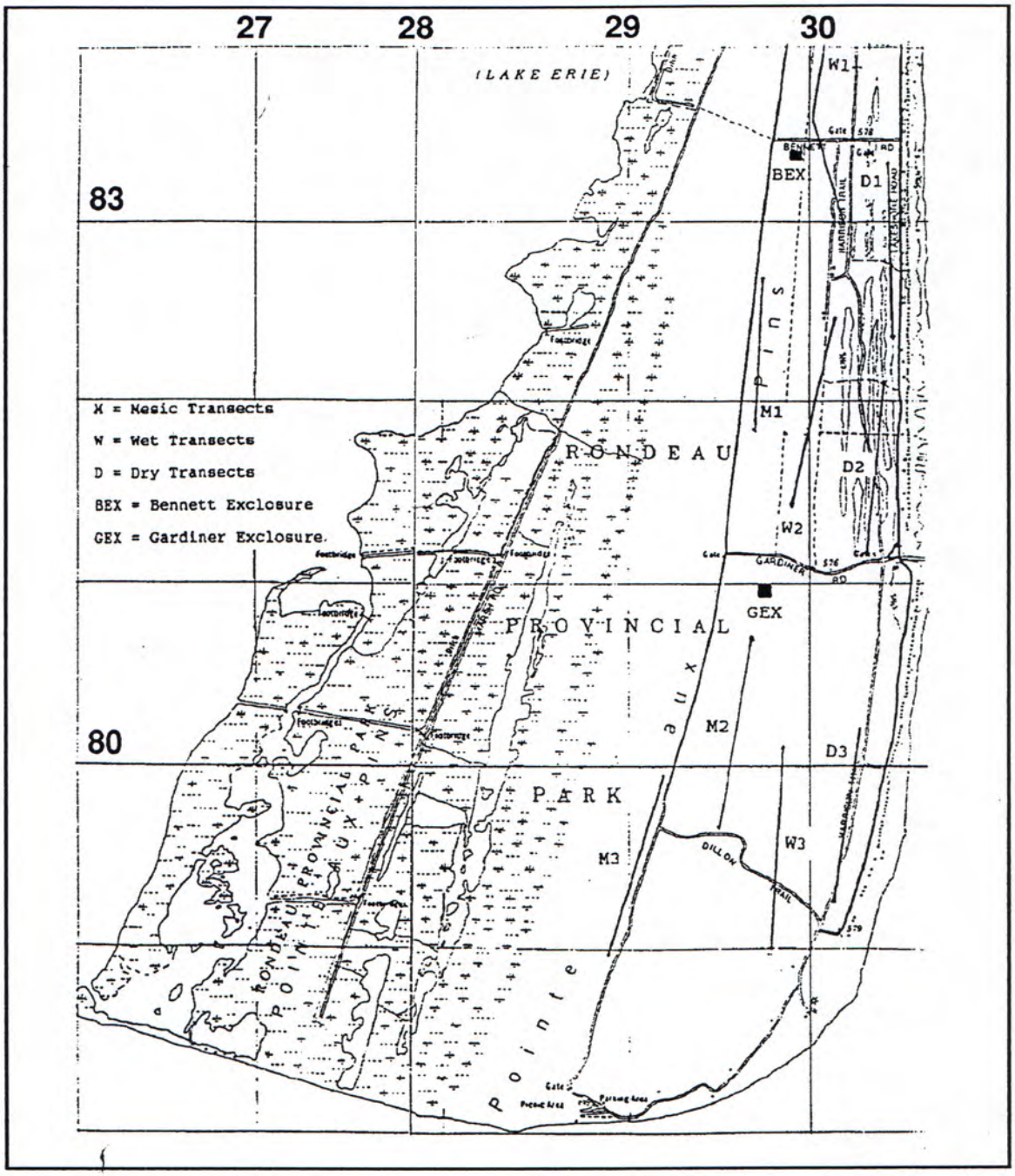
For the frequency data, the principal components showed similar loadings (Table 3b). However, the third component had a high loading for invasive species, and the second component had a high negative loading for understorey species found in a mature Carolinian forest.

B) Plant Community Composition in 1994

For the 1994 data set, the first three principal components in the analyses of the percent cover and frequency data explained over 60% of the total variation in the data (Table 4). After a Varimax Rotation of these three components, a plot was made of the first and second, second and third, and first and third components (Figures 7-9).

For the percent cover data, the first component had a high loading for species such as *Arisaema triphyllum,Circaea quadrisulcata, and Viola* spp. (Table 4a). This component showed a gradient from sites more disturbed by deer (e.g. floodplain forest at Pinery) to less disturbed sites (e.g. wet habitat at Rondeau; Figures 7 & 9). The second component had a high negative loading for species such as *Quercus* spp., *Euphorbia* spp., and *Helianthus divaricatus* (woodland sunflower; Table 4a), and separated oak-savannah from the other forest habitats (Figures 7-8). The third component had a high negative loading for several woodland species such as *Aster* spp., *Solidago* spp., seedlings of *Acer* spp., and *Polygonatum biflorum* (Table 4a).

For the frequency data, the components showed similar trends (Table 4b). The sign of the variables with the highest loadings were negative for the third component while they were positive for the analysis of the percent cover data. In both analyses, the exclosures in the dry habitat at Rondeau were distinguished from the other Rondeau sites, suggesting that their community composition was substantially different from mesic and wet sites but this difference was obscured in the 1992 analyses.



2.

Figure Locations of transects in the three habitat types, and the Bennett and Gardiner exclosures at Rondeau Provincial Park (UTM grid references shown).

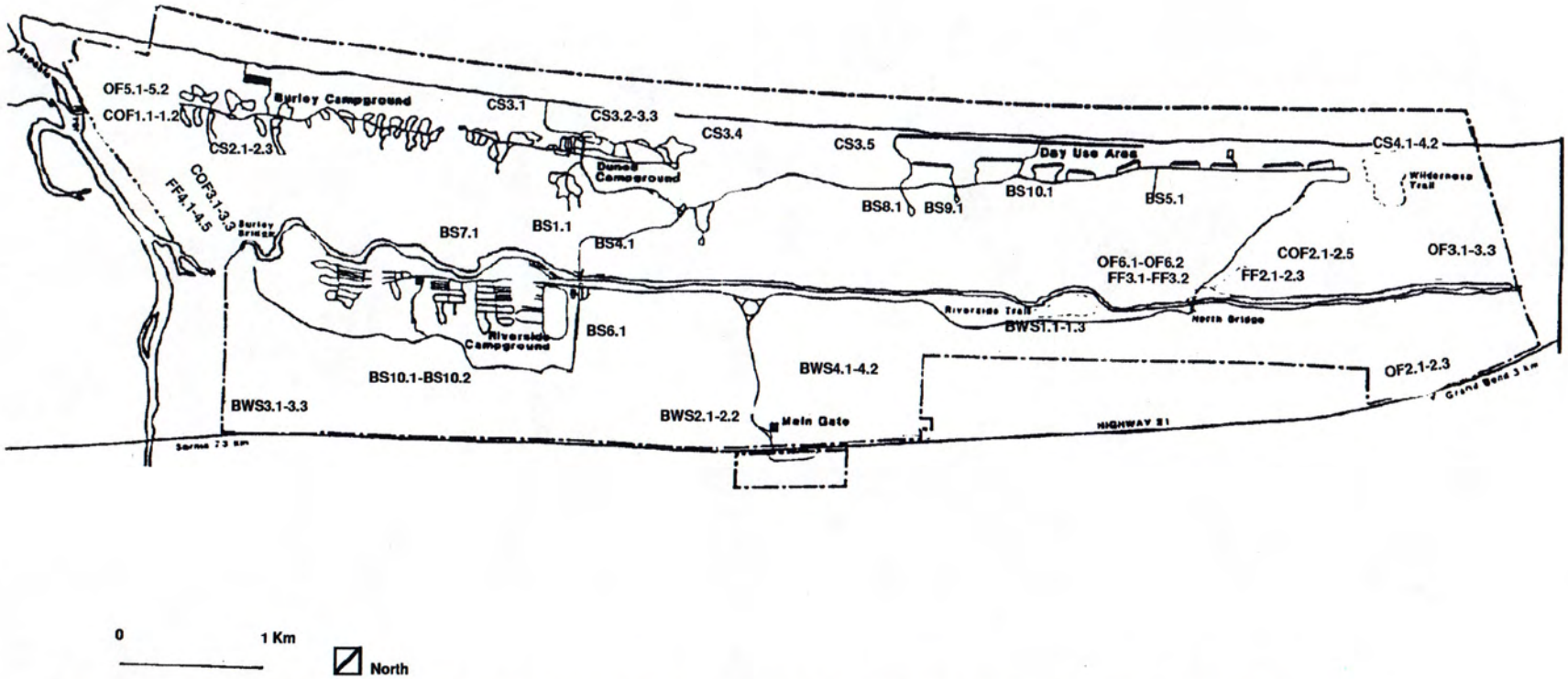


Figure 3. Map indicating sites for herbaceous plant cover study in 1994 at Pinery Provincial Park.
OF-oak forest; COF-conifer/oak forest; FF-floodplain forest; BWS-black/white oak savannah; BS-black oak savannah; CS-cedar savannah.

1-Dry North Exclosure
2-Dry South Exclosure
3-Dry Grazed
4-Mesic North Exclosure
5-Mesic South Exclosure
6-Mesic Grazed
7-Wet North Exclosure
8-Wet South Exclosure
9-Wet Grazed
10-Gardiner Exclosure
11-Gardiner Grazed
12-Bennett Exclosure
13-Bennett Grazed
14-Point Pelée Exclosure
15-Point Pelée Grazed
16-Hillman Sandhill Exclosure
17-Hillman Sandhill Grazed
18-Pinery Exclosure
19-Pinery Grazed
20-Backus Woods Exclosure
21-Backus Woods Grazed
22-Gartshore/Moulton Tract Exclosure
23-Gartshore/Moulton Tract Grazed
24-Sinclair's Bush Exclosure
25-Sinclair's Bush Grazed
26-Joker's Hill Exclosure
27-Joker's Hill Grazed
28-Maple Exclosure
29-Maple Grazed
30-Skunk's Misery Exclosure
31-Skunk's Misery Grazed

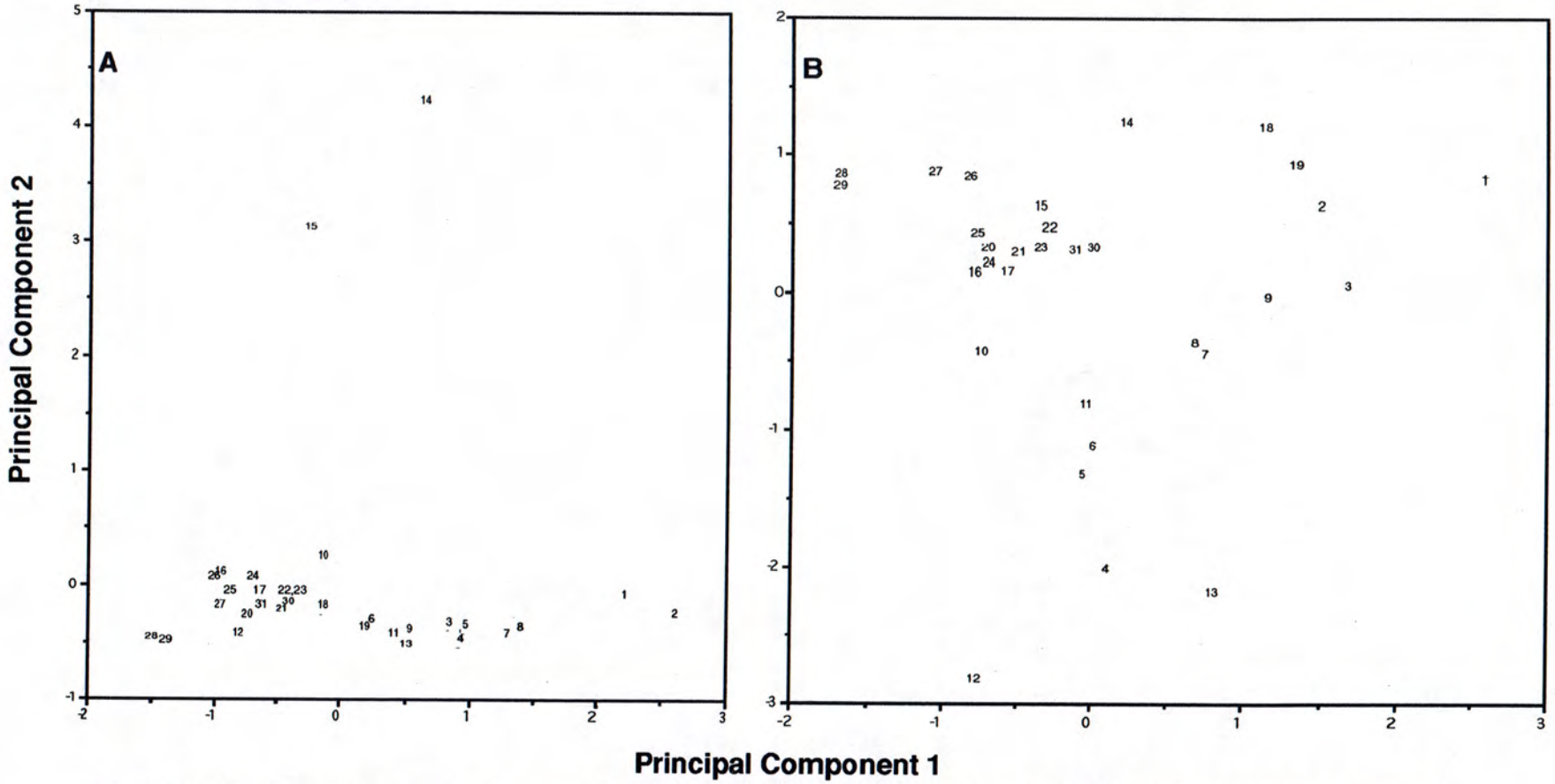


Figure 4. Plot of the first two components in principal component analyses of a) percent cover and b) frequency data of herbaceous communities in habitat types at Rondeau (1-13) and nine other locations across southern Ontario, 1992.

1-Dry North Exclosure
2-Dry South Exclosure
3-Dry Grazed
4-Mesic North Exclosure
5-Mesic South Exclosure
6-Mesic Grazed
7-Wet North Exclosure
8-Wet South Exclosure
9-Wet Grazed
10-Gardiner Exclosure
11-Gardiner Grazed
12-Bennett Exclosure
13-Bennett Grazed
14-Point Pelée Exclosure
15-Point Pelée Grazed
16-Hillman Sandhill Exclosure
17-Hillman Sandhill Grazed
18-Pinery Exclosure
19-Pinery Grazed
20-Backus Woods Exclosure
21-Backus Woods Grazed
22-Gartshore/Moulton Tract Exclosure
23-Gartshore/Moulton Tract Grazed
24-Sinclair's Bush Exclosure
25-Sinclair's Bush Grazed
26-Joker's Hill Exclosure
27-Joker's Hill Grazed
28-Maple Exclosure
29-Maple Grazed
30-Skunk's Misery Exclosure
31-Skunk's Misery Grazed

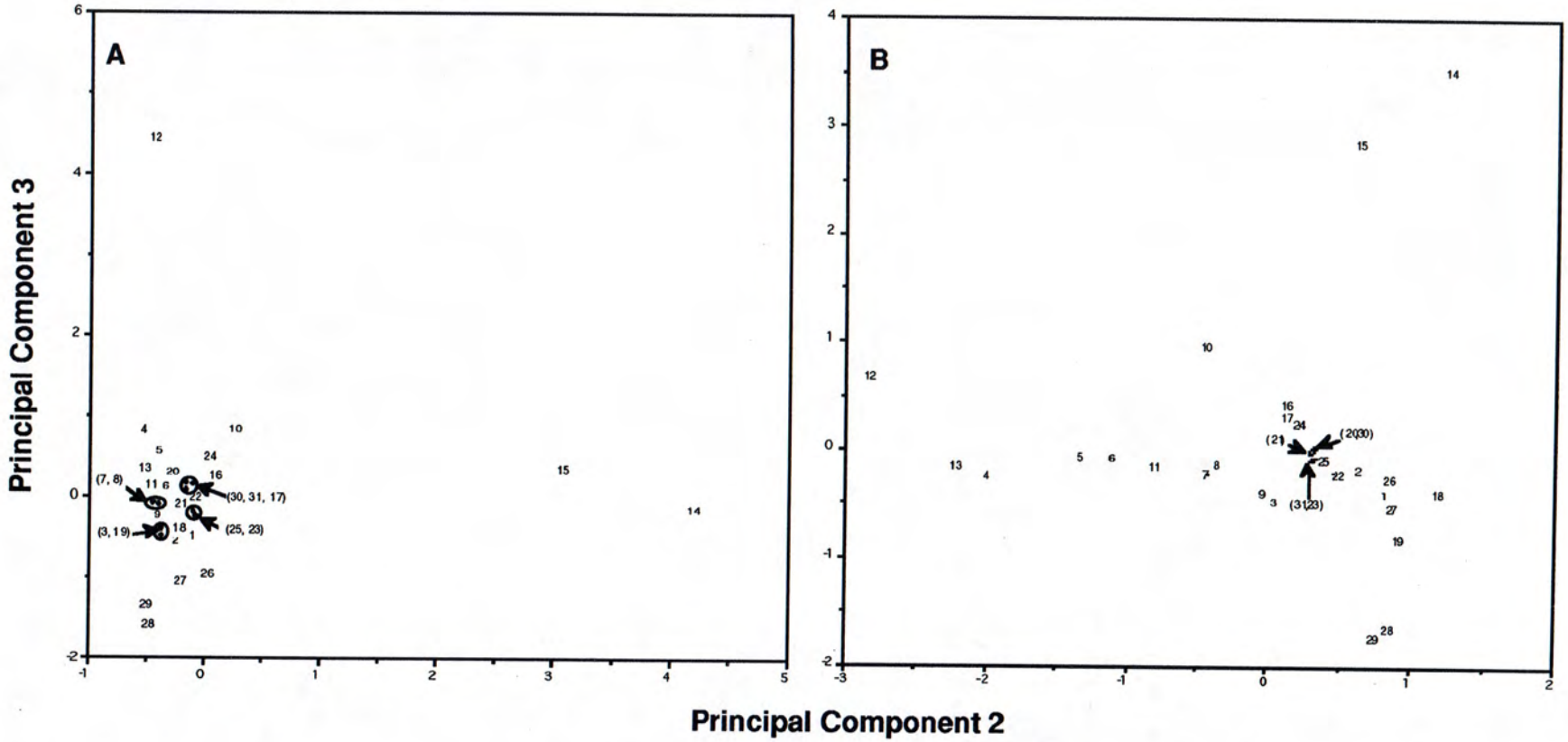


Figure 5. Plot of the second and third components in principal component analyses of a) percent cover and b) frequency data of herbaceous communities in habitat types at Rondeau (1-13) and nine other locations across southern Ontario, 1992.

1-Dry North Exclosure
2-Dry South Exclosure
3-Dry Grazed
4-Mesic North Exclosure
5-Mesic South Exclosure
6-Mesic Grazed
7-Wet North Exclosure
8-Wet South Exclosure
9-Wet Grazed
10-Gardiner Exclosure
11-Gardiner Grazed
12-Bennett Exclosure
13-Bennett Grazed
14-Point Pelée Exclosure
15-Point Pelée Grazed
16-Hillman Sandhill Exclosure
17-Hillman Sandhill Grazed
18-Pinery Exclosure
19-Pinery Grazed
20-Backus Woods Exclosure
21-Backus Woods Grazed
22-Gartshore/Moulton Tract Exclosure
23-Gartshore/Moulton Tract Grazed
24-Sinclair's Bush Exclosure
25-Sinclair's Bush Grazed
26-Joker's Hill Exclosure
27-Joker's Hill Grazed
28-Maple Exclosure
29-Maple Grazed
30-Skunk's Misery Exclosure
31-Skunk's Misery Grazed

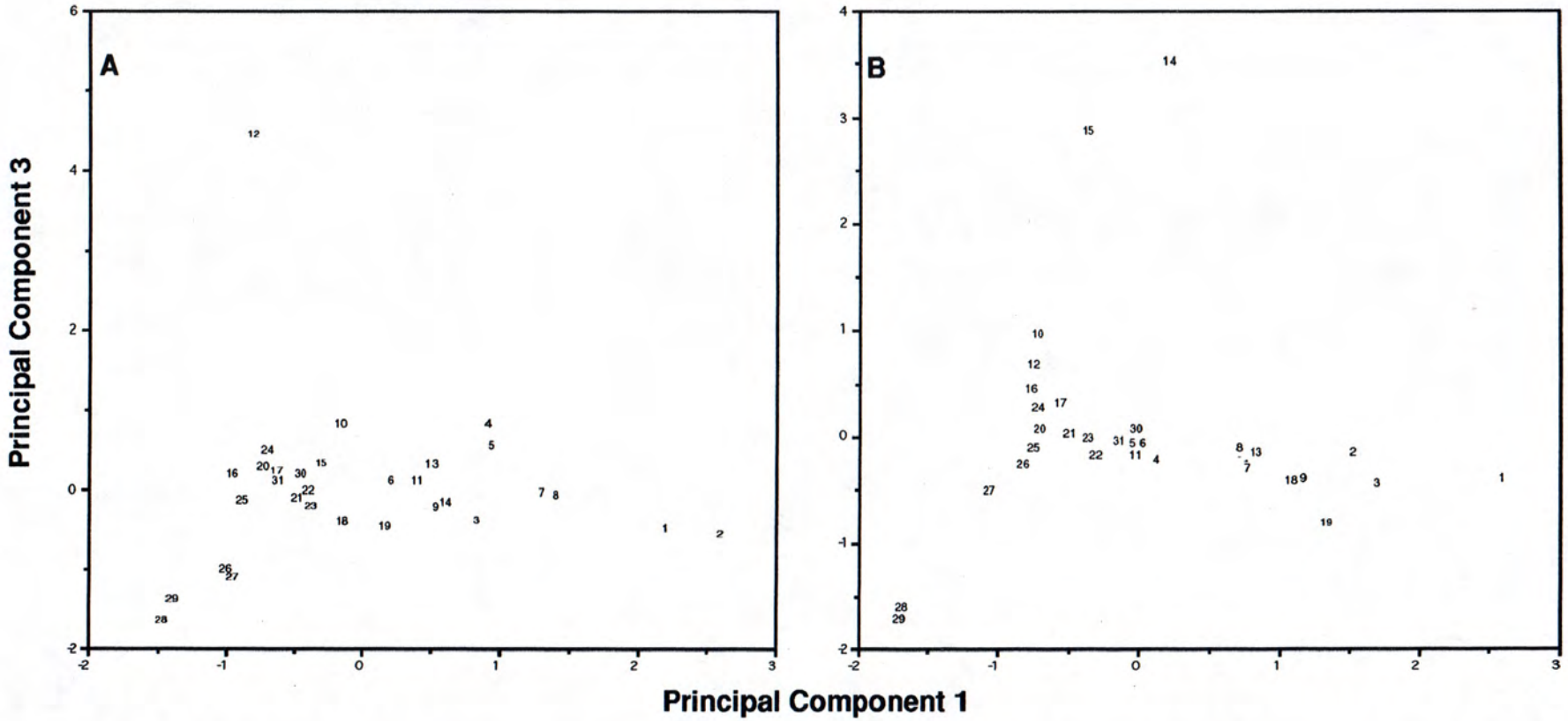


Figure 6. Plot of the first and third components in principal component analyses of a) percent cover and b) frequency data of herbaceous communities in habitat types at Rondeau (1-13) and nine other locations across southern Ontario, 1992.

1-Dry Exclosure
2-Dry Grazed
3-Mesic Exclosure
4-Mesic Grazed
5-Wet Exclosure
6-Wet Grazed
7-Black Oak Savannah Exclosure
8-Black Oak Savannah Grazed
9-Black & White Oak Savannah Exclosure
10-Black & White Oak Savannah Grazed
11-Cedar/Oak Savannah
12-Cedar/Oak Savannah
13-Cedar Savannah Exclosure
14-Cedar Savannah Grazed
15-Floodplain Forest Exclosure
16-Floodplain Forest Grazed
17-Oak Forest
18-Oak Forest

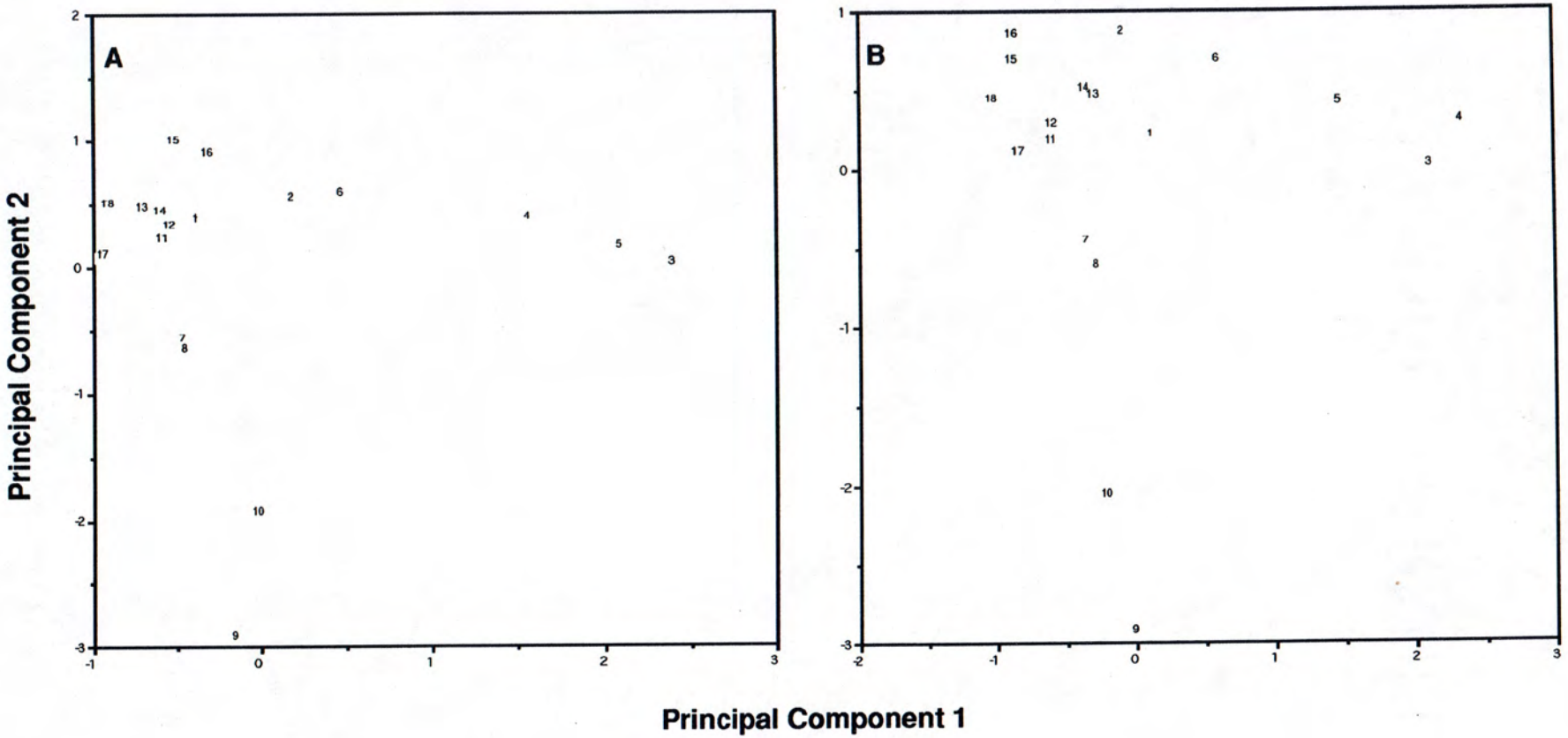


Figure 7. Plot of the first two components in principal component analyses of a) percent cover and b) frequency data of herbaceous communities in habitat types at Rondeau (1-6) and Pinery (7-18) Provincial Parks, 1994.

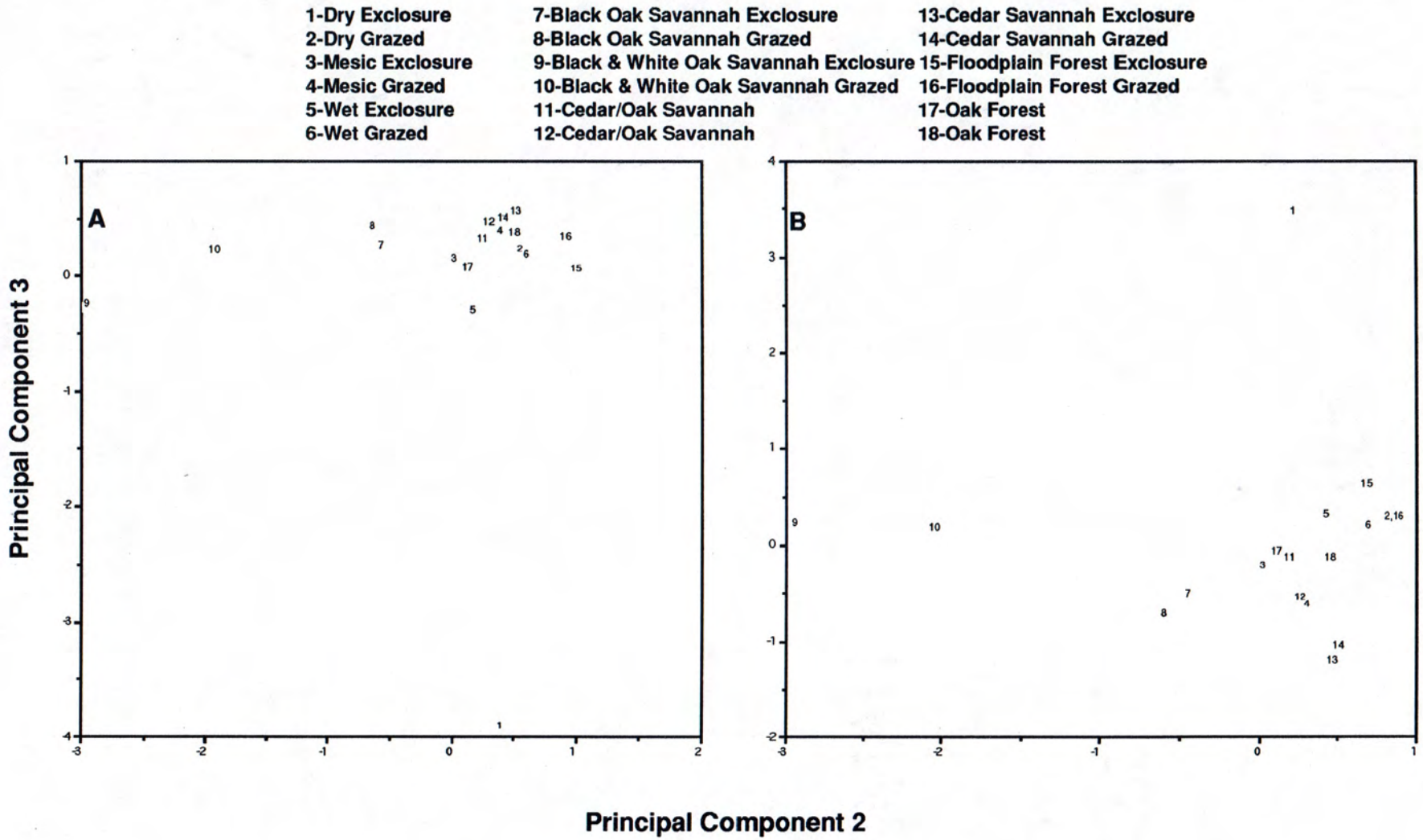


Figure 8. Plot of the second and third components in principal component analyses of a) percent cover and b) frequency data of herbaceous communities in habitat types at Rondeau (1-6) and Pinery (7-18) Provincial Parks, 1994.

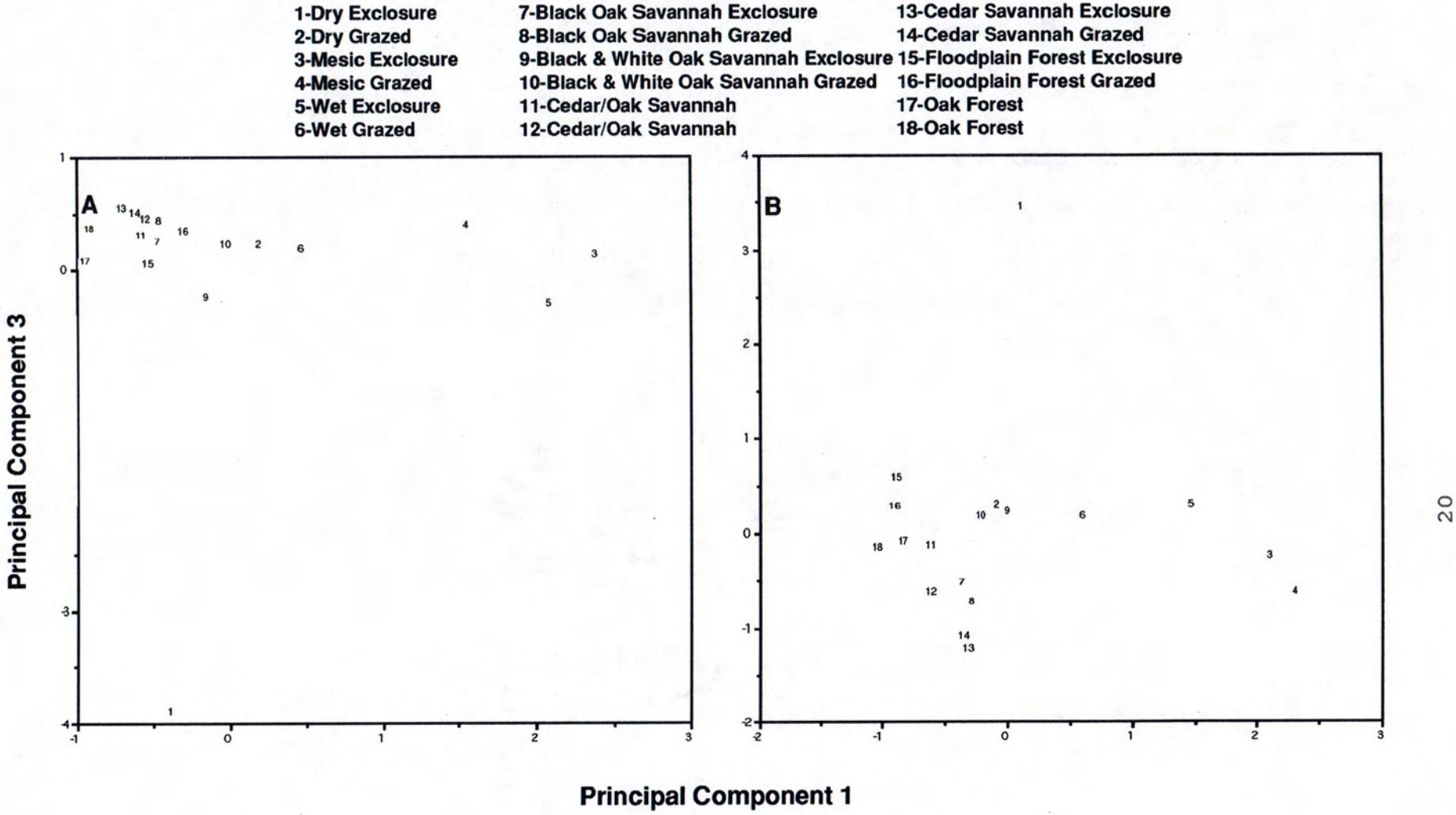


Figure 9. Plot of the first and third components in principal component analyses of a) percent cover and b) frequency data of herbaceous communities in habitat types at Rondeau (1-6) and Pinery (7-18) Provincial Parks, 1994.

Table 3. Loadings, percent variation explained, and Eigenvalues of the first three rotated principal components for the 1992 a) percent cover and b) frequency data.

A

	PC1	PC2	PC3
Percent:	20.54	19.34	12.73
Eigenvalue:	6.16	5.8	3.82
Eigenvectors:			
Acer spp.	-0.506	-0.116	-0.475
Alliariaofficinalis	-0.003	**0.958**	0.031
Aquilegia canadensis	**0.712**	0.175	-0.142
Arisaematriphyllum	-0.199	-0.122	**0.888**
Aster spp.	**0.762**	0.108	-0.153
Circaeaquadrisulcata	-0.082	-0.205	0.168
Claytoniavirginica	-0.546	-0.119	-0.468
Dentaria spp.	-0.18	-0.098	**0.833**
Dryopteris spp.	-0.24	-0.084	0.044
Erythronium americanum	-0.593	-0.082	-0.225
Fagus spp.	0.541	-0.062	0.102
Fraxinus spp.	-0.385	-0.183	-0.378
Galium4	**0.78**	-0.244	0.011
Galium6	**0.68**	0.096	-0.029
Geraniummaculatum	0.252	-0.185	-0.01
Geraniumrobertianum	0.014	**0.978**	0.011
Geum spp.	0.137	**0.961**	0.017
Graminoids	**0.812**	-0.278	-0.208
Lindera benzoin	0.375	-0.164	0.327
Liriodendron tulipifera	**0.818**	-0.242	-0.051
Maianthemum canadense	-0.255	-0.137	0.34
Osmorhiza claytoni	0.046	**0.908**	0.066
Parthenocissus quinquefolia	-0.284	0.352	**0.643**
Polygonatum biflorum	-0.022	**0.626**	-0.144
Solidago spp.	0.413	0.276	0.137
Stellaria spp.	0.047	**0.969**	0.015
Trillium spp.	-0.44	-0.148	-0.363
Unknown Woody	-0.224	0.289	0.099
Viola spp.	0.363	-0.244	**0.68**
Vitis spp.	0.289	0.201	**0.662**

B

	PC1	PC2	PC3
Percent:	20.27	16.32	14.96
Eigenvalue:	5.27	4.24	3.89
Eigenvector:			
Acer spp.	-0.59	0.299	-0.451
Alliaria officinalis	-0.064	0.262	**0.833**
Aquilegia canadensis	**0.758**	0.248	-0.056
Arisaematriphyllum	-0.128	**-0.749**	0.125
Aster spp.	**0.764**	0.23	-0.076
Circaea quadrisulcata	-0.05	-0.541	-0.193
Claytonia virginica	-0.571	0.312	-0.464
Dentaria spp.	-0.132	-0.589	0.114
Dryopteris spp.	-0.198	0.012	0.041
Erythronium americanum	-0.586	0.319	-0.273
Fagus spp.	**0.754**	-0.03	-0.157
Fraxinus spp.	-0.003	0.31	-0.574
Geranium maculatum	**0.621**	0.198	-0.248
Geranium robertianum	-0.079	0.268	**0.837**
Geum spp.	0.134	0.119	**0.828**
Lindera benzoin	0.195	**-0.846**	-0.055
Liriodendron tulipifera	0.584	-0.441	-0.172
Maianthemumcanadense	-0.33	0.159	-0.189
Osmorhiza claytoni	-0.124	0.009	0.587
Parthenocissus quinquefolia	-0.236	-0.26	0.509
Polygonatum biflorum	0.294	0.477	0.282
Solidago spp.	0.053	-0.449	0.107
Trillium spp.	-0.502	0.17	-0.464
Unknown Woody	0.589	0.307	0.036
Viola spp.	0.105	**-0.909**	-0.015
Vitis spp.	0.523	-0.559	-0.065

Those species that loaded highest in each principal component are shown in bold.

Table 4. Loadings, percent variation explained, and Eigenvalues of the first three rotated principal components for the 1994 a) percent cover and b) frequency data.

A

	PC1	PC2	PC3
Percent:	32.22	18.49	12.47
Eigenvalue:	10.96	6.29	4.24
Eigenvectors:			
Acer spp.	0.065	0.129	**-0.961**
Aquilegia canadensis	0.096	0.104	**-0.656**
Arctostaphylos uva-ursi	-0.238	0.164	0.189
Arisaema triphyllum	**0.806**	-0.112	-0.002
Aster spp.	0.194	0.081	**-0.879**
Circaea quadrisulcata	**0.717**	0.286	-0.209
Cyperaceae (family)	-0.064	0.383	0.096
Euphorbia spp.	-0.083	**-0.938**	-0.009
Fraxinus spp.	0.127	0.473	-0.069
Galium lanceolatum	**0.803**	0.156	-0.491
Galium pilosum	-0.149	**-0.953**	0.043
Galium triflorum	0.584	0.155	**-0.664**
Geranium maculatum	-0.13	-0.132	**-0.848**
Graminoids	**-0.607**	-0.203	0.171
Hamamelis virginia	-0.412	0.169	0.17
Helianthus spp.	-0.089	**-0.939**	-0.004
Lindera benzoin	**0.903**	0.086	0.041
Liriodendron tulipifera	**0.713**	0.299	0.018
Maianthemum canadense	0.082	-0.457	**-0.775**
Melampyrum lineare	-0.124	**-0.911**	0.014
Osmorhiza claytoni	**0.802**	0.049	-0.008
Parthenocissus quinquefolia	0.493	0.337	**-0.611**
Polygonatum biflorum	-0.013	0.111	**-0.982**
Prunus spp.	-0.339	**-0.662**	0.085
Quercus spp.	-0.193	**-0.83**	0.075
Rhus radicans	-0.095	**-0.716**	0.111
Sanicula marilandica	0.08	**-0.731**	0.044
Senecio spp.	-0.234	**-0.66**	0.099
Smilax herbacea	**0.817**	0.093	-0.178
Solidago spp.	0.554	0.065	**-0.772**
Taraxacum spp.	-0.374	0.359	0.143
Unknown Woody	0.525	-0.024	-0.019
Viola spp.	**0.904**	0.139	0.008
Vitis spp.	0.45	0.26	-0.076

B

	PC1	PC2	PC3
Percent:	35.6	16.32	11.17
Eigenvalue:	11.39	5.22	3.57
Eigenvector:			
Acer spp.	0.209	0.234	**0.792**
Aquilegia canadensis	-0.021	0.179	0.411
Arctostaphylos uva-ursi	-0.121	0.175	-0.412
Arisaema triphyllum	**0.786**	0.168	-0.069
Aster spp.	-0.025	0.057	**0.88**
Circaea quadrisulcata	**0.674**	0.211	0.479
Euphorbia spp.	-0.055	**-0.949**	0.028
Fraxinus spp	-0.315	0.462	0.335
Galium lanceolatum	**0.842**	0.204	0.443
Galium pilosum	-0.135	**-0.86**	-0.108
Galium triflorum	**0.66**	0.189	**0.641**
Geranium maculatum	-0.144	-0.282	**0.634**
Hamamelis virginia	-0.422	0.145	-0.15
Helianthus spp.	-0.055	**-0.953**	0.026
Lindera benzoin	**0.924**	0.13	-0.121
Liriodendron tulipifera	0.404	0.353	0.157
Maianthemum canadense	0.343	-0.102	**0.82**
Melampyrum lineare	-0.107	**-0.939**	0.018
Osmorhiza claytoni	**0.887**	0.088	0.03
Parthenocissus quinquefolia	0.584	0.355	**0.609**
Polygonatum biflorum	0.242	0.182	**0.835**
Prunus spp.	-0.468	-0.597	-0.074
Quercus spp.	-0.303	**-0.857**	-0.074
Rhus radicans	-0.2	**-0.676**	-0.147
Sanicula marilandica	-0.03	**-0.883**	0.037
Senecio spp.	-0.168	-0.366	-0.394
Smilax herbacea	0.586	0.228	0.184
Solidago spp.	**0.808**	0.119	0.44
Taraxacum spp.	-0.531	0.298	0.079
Unknown Woody	0.505	0.199	0.223
Viola spp.	**0.795**	0.22	-0.008
Vitis spp.	0.358	0.351	0.209

Those species that loaded highest in each principal component are shown in bold.

3. Searches for Rare and Native Plant Species Search

PURPOSE

This survey of rare and native plant species, which builds on a pilot study carried out in 1993, will provide a baseline for monitoring the recovery of rare species following the herd reduction in winter 1993.

DATES & LOCATIONS

June-August 1994: Rondeau Provincial Park.

METHODS

The 1994 search for rare plant species at Rondeau Provincial Park was carried out from June 17 to August 8 with the highest search effort concentrated in July when the majority of species flowered. These rare plant species are part of the "Ontario Rare Species List " (Argus et al., 1982-1987). Our searches also included native plant species which had been recorded at Rondeau but had not been seen in the recent past (last 3-10 years) presumably due to removal by deer. Searches were conducted by members of our research team with the help of several park naturalists.

We searched for the following:

a) rare species: *Asclepias exaltata, Asclepias verticillata, Asclepias viridiflora, Coreopsis lanceolata, Habernaria clavellata, Habernaria flava, Orchis spectabilis, Pyncanthemum pilosum,* and *Triphora trianthophora.*

b) native species: *Asclepsias incarnata, Blephilia hirsuta, Chrysopsis mariana, Desmodium glutinosum, Koellia flexuosa, Lespedeza capitata, Liatris cylindracea, Lilium philadelphicum, Lithospermum canescens, Lobelia spicata, Meibomia canadensis, Mimulus ringens,* and *Verbena hastata.*

Searches were done by two to three person teams at locations where a species had previously been reported (Al Woodliffe, O.M.N.R., Chatham; pers. comm.). At these locations, the area was divided into quadrants and using parallel transects, we searched the area. We searched for up to 30 minutes for a species in a location and if the plant was not found in that time, the search was extended by 15-20 minutes. Because some species flowered at different times, searches were carried out over the summer to coincide with flowering. Each individual plant found during a search was marked. However, if there were a number of individuals at a

single site, one individual was tagged with blue flagging tape. The general location and site were flagged as well.

RESULTS

For the first time during four years of research by Koh, Bazely, and Voigt at Rondeau Provincial Park, *Orchis spectabilis* (Showy Orchis) was seen flowering. This provided another indication of Rondeau's recovery from intense deer grazing. Table 5 provides a complete summary of the findings from the 1994 searches.

Table 5. A summary of the rare species searches in 1994. HT-Harrison Trail; LS-Lakeshore Drive; MT-Marsh Trail.

DATE	TIME(SEARCH)		SPECIES	STATUS	LOCATION	# INDIVIDUALS
	START	STOP				
Jun 17	11:38	12:14	*Habernia flava*	Rare	200 m south of pony barn on HT; clearing on the west side	none
Jun 17	13:58	14:20	*Lilium philadelphicum*	Native	200 m south of pony barn on HT; clearing on the west side	none
Jun 17	14:29	15:27	*Orchis spectabilis*	Rare	on both sides along length of Spicebush Trail	none
Jun 23	10:25	11:09	*Orchis spectabilis*	Rare	southwest corner 5 m past the 3rd pole of Bennett exclosure	5 unmarked
Jun 23	10:03	10:29	*Lilium philadelphicum*	Native	in field west of Visitors Services building	2 unmarked
Jul 11	10:35	11:00	*Desmodium glutinosum*	Native	on the west side of HT south of the pony barn	25+
Jul 11	11:10	11:35	*Lobelia spicata*	Native	on HT past Bennett, 5 m east off the roadside	13+
Jul 11	11:47	12:09	*Blephilia hirsuta*	Native	on HT, westside	10+
Jul 11	12:15	12:42	*Lithospermum canescens*	Native	south point off bend of HT going north on the west side	20+
Jul 18	14:01	14:05	*Chrysopsis mariana*	Native	200 m east on HT	1 unmarked
Jul 18	13:52	14:08	*Asclepias viridiflora*	Rare	200 m west side on HT south of pony barn	none
Jul 18	14:10	14:25	*Pyncanthemum pilosum*	Rare	150-175 m south of pony barn on HT	16 unmarked
Jul 18	14:29	14:50	*Desmodium glutinosum*	Native	east & west side of HT starting south of pony barn	50 unmarked
Jul 18	15:25	16:00	*Asclepias exaltata*	Rare	50 m east side of HT north of Gardiner	none
Jul 20	10:00	10:37	*Asclepias verticillata*	Rare	east of MT 70 m south of 2nd parking lot	none
Jul 20	11:00	11:45	*Habernia flava*	Rare	200 m south of pony barn east of HT yellow tagged tree	none
Jul 20	13:45	14:30	*Triphora trianthophora*	Rare	300 m north of Gardiner on HT; pine stump east side	none
Jul 20	15:05	15:27	*Mimulus ringens*	Native	west side of HT south from Bennett	present
Jul 20	15:40	16:09	*Asclepias exaltata*	Rare	100 m east side on HT north of Gardiner	none
Jul 21	9:30	10:45	*Asclepias viridiflora*	Rare	Visitor Services for location information	none
Jul 21	11:00	12:00	*Coreopsis lanceolata*	Rare	along edge of pine/oak forest across from lot 260 LS Rd	none
Jul 25	11:55	12:00	*Meibomia canadensis*	Native	all along west side of MT	50+
Jul 25	12:07	12:15	*Asclepias incarnata*	Native	2nd parking lot on MT west side	1 unmarked
Jul 25	12:52	13:13	*Verbena hastata*	Native	2nd parking lot MT west side	1 unmarked
Aug 01	11:39	13:00	*Habernia flava*	Rare	200 m south of pony barn on HT	1 marked
Aug 01	13:45	14:22	*Liatris cylindracea*	Native	200 m south of pony barn east of HT	1 unmarked
Aug 08	10:49	11:34	*Koellia flexuosa*	Native	on HT southwest side 500 m past pony barn	1 unmarked
Aug 08	11:56	12:45	*Lespedeza capitata*	Native	in clearing east of HT 200 m south	1 unmarked

4. Plant Height as an Indicator of Grazing Pressure by White-Tailed Deer

PURPOSE

This study determined whether the height of particular plant species reflected the general grazing pressure on the herbaceous plant community in Rondeau Park, and whether these species would be suitable as indicators of recovery following the deer herd reduction in winter 1993.

DATES & LOCATIONS

August-September 1994: Rondeau Provincial Park.

METHODS

Five plant species were selected after a brief survey of the thirty sets of plots (one set of plots comprised: two ungrazed exclosures, NEX, and one grazed site, RON) to determine the most common, widespread species. The variable of interest was change in plant height following reduction in grazing pressure. This could be tracked in the exclosures of different age. A major factor influencing the choice of species was whether they were likely to be grazed by deer.

Four herbaceous species and one vine were selected for study. These were:

Enchanter's Nightshade, *Circaea quadrisulcata* ;

Jack-in-the-pulpit, *Arisaema triphyllum*;

Canada Mayflower, *Maianthemum canadense*;

Solomon's Seal, *Polygonatum biflorum*;

Poison Ivy, *Rhus radicans*;

Plant heights were measured from August 23 to September 4 1994 in mesic, wet and dry sites. In each of these sites there were ten sets of plots. One set of plots included two recently established exclosures, built in 1991 and 1994, and their adjacent grazed sites. Heights were also measured at the exclosures built in 1978 at the Bennett and Gardiner Road sites. For the mesic, wet and dry sites, the protocol was as follows:

At each set of plots we attempted to measure a total of 30 plants of each species;

-ten in the 1991 NEX exclosure,

-ten in the 1994 NEX exclosure that had been moved from its 1991 position

in May 1994,

-ten in the adjacent grazed (RON) plot.

The boundary used to define the grazed (RON) plot in relation to the exclosures is illustrated in Figure 10a. The grazed plot surrounded the two exclosures by 2 m and also included the area in between the two exclosures. See section I for a description of the transects along which the sets of plots were located.

If more than ten individuals of one species occurred in a plot, plants to be measured were selected using a combination of stratified and random sampling methods as follows. The number of patches of a species in a plot was estimated, and the number of individuals to be sampled at random in a patch was calculated in proportion to the size of the patch relative to the total plot population. In the case of the grazed plot, if the species was numerous and evenly distributed throughout the plot, three to four plants were randomly selected at either end of the plot and the remaining three to four plants were randomly selected from between the exclosures. The height of an individual plant was measured in centimetres from the point at which the stem left the material in which it was growing, to the point at which the longest stem of a group joined the leaf (Figure 11). Height to flower was also recorded where present for *Circaea quadrisulcata*.

In Bennett (BEX) and Gardiner (GEX) exclosures, built in 1978, five co-ordinates were selected at random along the north and south boundary fences of each exclosure. If the selected co-ordinate was close to a quadrat from the long-term studies of *Trillium*, *Arisaema*, and *Viola*, a new one was chosen. Low-lying wet areas along the boundary fence were also avoided. At each co-ordinate, a ten metre transect was set up on each side of the fence starting at a distance of three metres away from the fence (Figure 10b). Individuals of each species located at a distance of one metre or less from the transect were measured.

RESULTS

Plant heights were pooled within plot types (NEX-1991, NEX-1994 and RON-grazed plots) within in mesic, wet and dry sites. They were analyzed using a nested (split-plot) ANOVA. Overall there was no significant among-site variation and mean plant heights tended to be similar on average across Bennett, Gardiner, dry, mesic and wet sites (Figure 12; Table 6). There were significant differences among treatments within sites for all five plant species measured. Thus, protection from grazing had a significant impact on plant height within most sites.

Table 6. Results of nested ANOVA's for plant height.

	Among site variation	Among plots (exclosures) within sites
Circaea quadrisulcata	$F_{4,7} = 0.21$ n.s.	$F_{7,473} = 14,6^{***}$
Arisaema triphyllum	$F_{3,6} = 0.97$ n.s.	$F_{6,410} = 10.4^{***}$
Maianthemum canadense	$F_{4,8} = 1.48$ n.s.	$F_{8,570} = 12.3^{***}$
Polygonatum biflorum	$F_{4,8} = 0.34$ n.s.	$F_{8,461} = 47.5^{***}$
Rhus radicans	$F_{4,8} = 0.48$ n.s.	$F_{8,257} = 5.0^{***}$

n.s.-non-significant; ***p<0.001

Plants varied in response to decreased grazing in exclosures. Thus species varied in their suitability as an indicator of release from grazing pressure. For example, *Rhus radicans* responded best to grazing protection in 1991 exclosures in mesic and wet sites, but elsewhere there was no significant difference among grazed and ungrazed plots within sites. This indicated that deer grazing suppressed the growth of *Rhus radicans* only in wet and mesic sites, but elsewhere growth may have been limited by soil type and shade even in the absence of grazing. Similarly, *Maianthemum canadense* responded best to grazing protection in Bennett, Gardiner and dry sites but did not respond at all to protection in mesic and wet sites, suggesting that other factors were more important in determining growth at the latter sites. *Arisaema triphyllum* seemed to respond slowly to protection from grazing and did not occur in dry sites.

In addition to *Trillium grandiflorum*, the subject of a long-term study (Koh, Bazely and Voigt 1995), the two most promising other candidates for indicator species were *Circaea quadrisulcata* and *Polygonatum biflorum.* They were both present across all sites and both showed a rapid positive response to protection from grazing in recent (1991) exclosures. This response was maintained in the older (1978) exclosures. Our failure to find a significant height difference between grazed and exclosures sites at Bennett for *P. biflorum* was explained by the small sample sizes (grazed n = 8 and exclosure n = 6 plants).

It was clear from this study that an ideal species for indicating recovery of "mature" forest habitat from deer herbivory is one having 1) a wide distribution across soil types and 2) a rapid growth response to protection from herbivory that is maintained over a number of years. Thus the ideal candidate is a long-lived, shade tolerant forest understorey species.

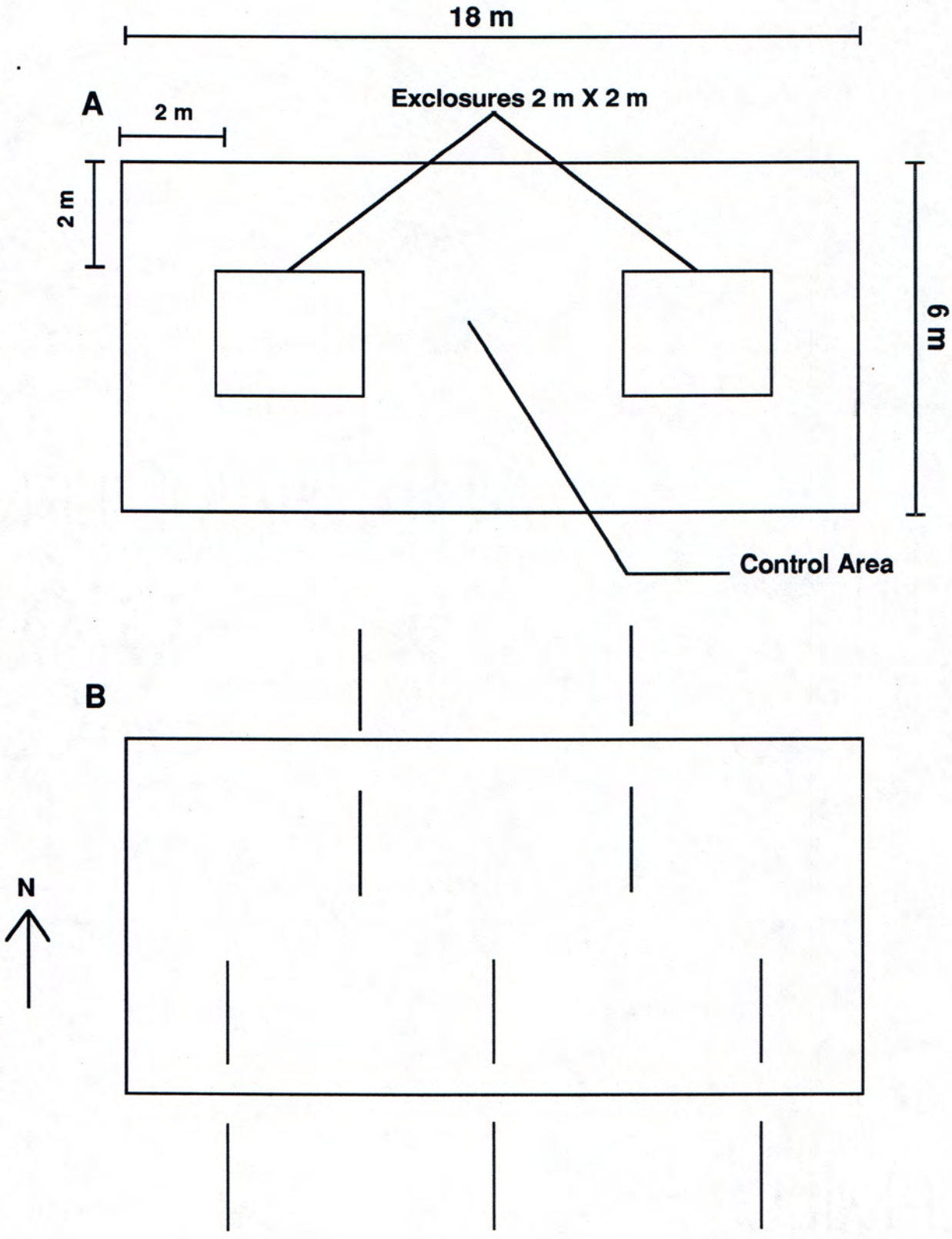


Figure 10. The locations where plants were measured at a) dry, wet, and mesic sites and b) Bennett and Gardiner sites.

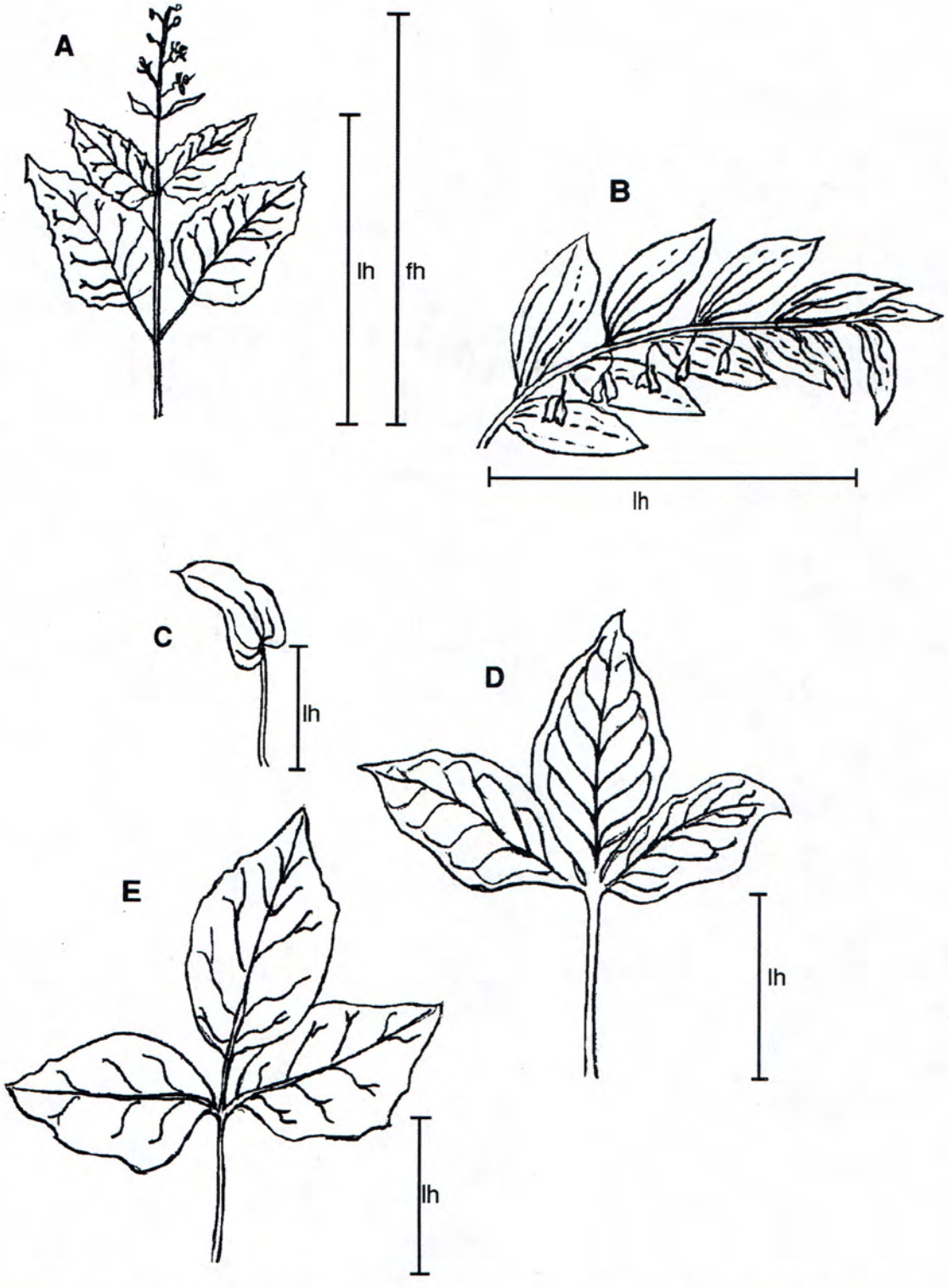


Figure 11. Parts of plant used for leaf height (lh) measurements: a) *Circaea quadrisulcata* (Enchanter's Nightshade), b) *Polygonatum biflorum* (Solomon's Seal), c) *Maianthenum canadense* (Canada Mayflower), d)*Arisaema* spp. (Jack-In-The-Pulpit), and e) *Rhus radicans* (Poison Ivy). Flower heights (fh) were available for only a small number of*C. quadrisulcata*.

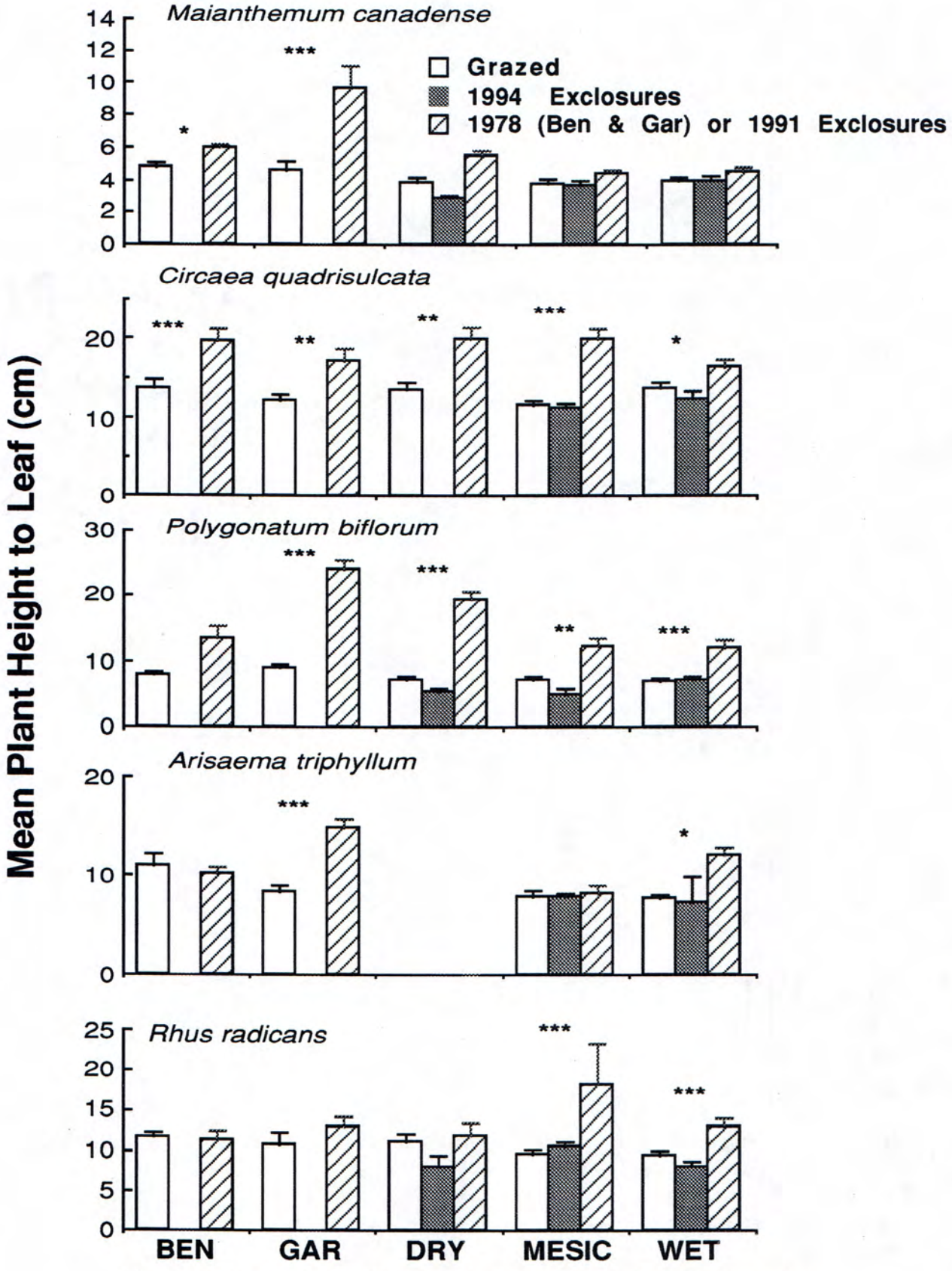


Figure 12. The mean plant height to leaf of the indicator species at Rondeau Provincial Park in the dry, mesic, wet, Bennett, and Gardiner sites.
*p < 0.05; **p < 0.01; ***p < 0.001

5. Determining Methods to Control Garlic Mustard, *Alliaria officinalis* at Rondeau Provincial Park

PURPOSE

Garlic mustard *(Alliaria officinalis)* is an exotic member of the mustard family. It is a biennial with small white flowers appearing from spring to early summer (Newcomb, 1977). It can be found along roadsides and areas of forest with sparse canopy or canopy gaps. A single plant produces an average of 164 seeds (Fridd, 1994). The early germination of garlic mustard in the spring gives the seeds a head start over many native species. It forms dense patches against which most native species seem unable to compete.

Plant naturalists, scientists, and visitors have noticed an increasing abundance of *A. officinalis* at Rondeau Provincial Park. In 1994, it was observed along Lakeshore Road between Gardiner and Bennet, in dense patches south of the clearing where the old pony barn stands on Harrison Trail, and at exclosure plot M3.3 on the South Point Trail.

Plans to find effective means of controlling the garlic mustard populations were proposed and carried out in an on going attempt to maintain and, in some cases, restore the diversity of native species in the park.

DATES & LOCATIONS

June-July 1994: Rondeau Provincial Park.

METHODS

Ten garlic mustard sites were selected (Figure 13). Sites with an even density of plants were selected. Sites were large enough to allow placement of a square cluster of four 1 m^2 test quadrats (one block) with an inter-quadrat distance of 1 to 2 m from at least one other quadrat.

Within each site, we attempted to plot locations so that the density of garlic mustard was approximately the same in each of the four quadrats (i.e. with each block). However, due to limited site availability it was not always possible to meet this criterion. Stakes were placed at diagonally opposite corners of each quadrat to delimit the plot's boundaries. A 2 m wide buffer zones was created around each individual quadrat, as well a around the entire cluster of quadrats by pulling or cutting any flowering *A. officinalis* to prevent any surrounding plants from seeding into the test plots.

Density of plants in quadrats was determined by counting the number of stems in one quarter of a quadrat and then multiplying by four to give an estimate of the number of stems/m^2. When the distribution of stems in the quadrat was uneven, all stems were counted. The average stem height for each quadrat was determined by measuring the height of ten randomly selected plants in each quadrat.

At each site, one of four treatments was randomly assigned to each of the four quadrats. Treatments were: 1) cutting, 2) pulling, 3) spraying with Roundup (i.e. Glyphosate), and 4) control. Pulling out the garlic mustard took place on June 29, spraying on June 30, and cutting on July 3, 1994.

1) Cutting was performed using garden shears. Plants were cut at a height of 10-15 cm from the ground. Since the plants had already produced seed pods in most cases, the garlic mustard was carefully disposed of so as to minimize the chance of the seed pods falling into the quadrats.

2) As the root system of garlic mustard is small and grows vertically down into the soil, pulling the plant out of the soil involved simply grasping the stem and pulling it up. This method was effective in leaving other species within the quadrat undisturbed, and stems and roots of *A. officinalis* plants were not separated, minimizing the chance of roots systems being left behind to shoot up again the following year. As with cutting, care was taken to remove all stems and to transport them away from the sites.

3) Spraying was performed on a calm, dry day so that there was minimal chance of herbicide spray being washed off the leaves, or of the spray being blown onto other plant species. The spray was always aimed away from the direction of other garlic mustard plots in a block. Roundup should be applied during the growing season. However, because of the time at which the spraying took place, the leaves of some of the plants were beginning to senesce and die.

RESULTS

The outcome of these tests will be determined in the 1995 field season. Our findings will be helpful in determining methods of any large scale *A. officinalis* control programme implemented in the park. Continued monitering of the 1994 *A. officinalis* test blocks will take place along with possible new control methods developed from our findings.

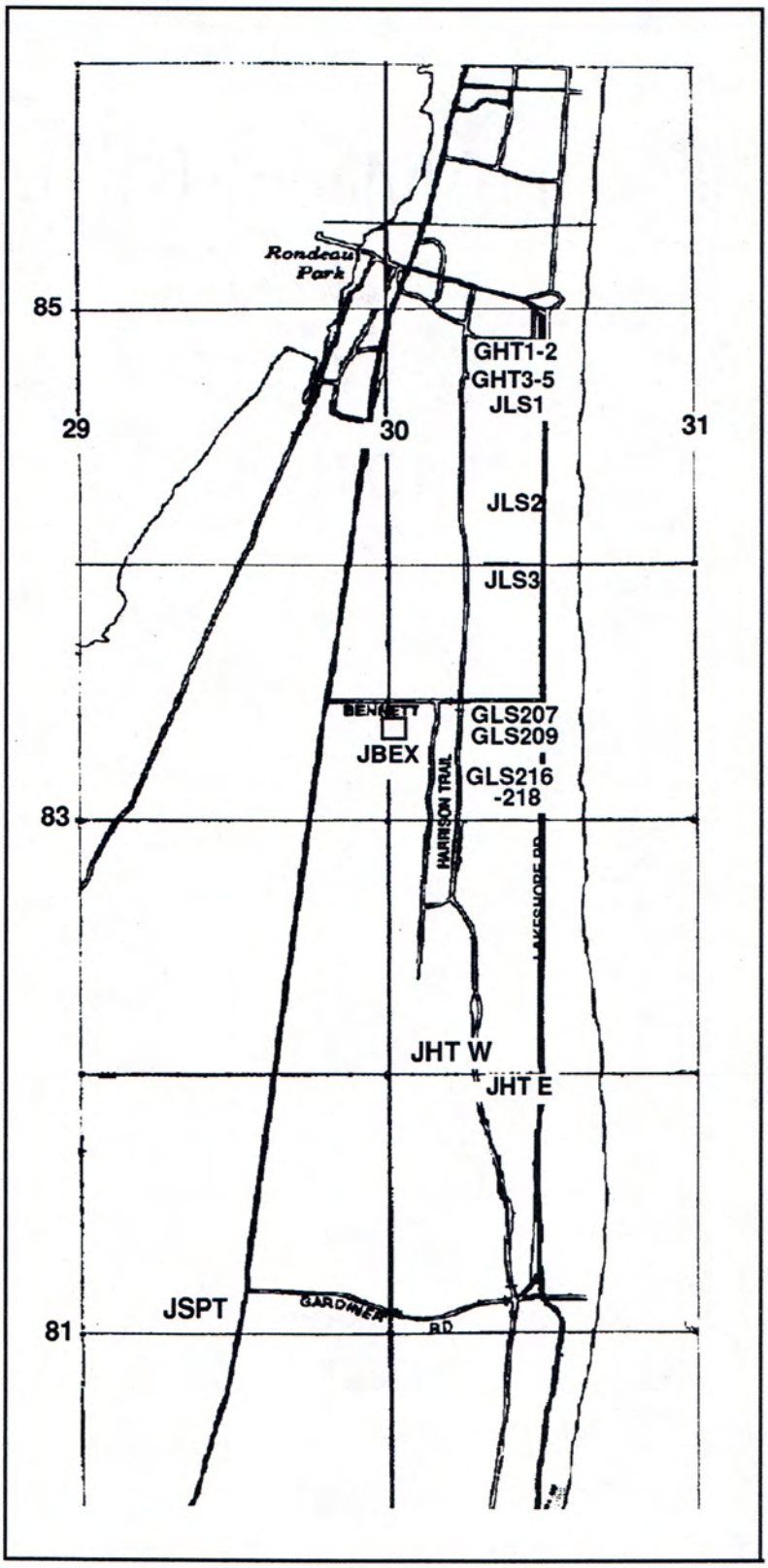


Figure 13. Locations of treatment plots for tests to control garlic mustard (G-) and Japanese barberry (J-). HT-Harrison Trail; LS-Lake Shore Road; SP-Southern Point Trail (UTM grid references shown).

6. Determining Methods for the Eradication of Japanese Barberry, *Berberis thunbergii* at Rondeau Provincial Park

PURPOSE

A series of experiments were carried out to test various methods for the removal of *Berberis thunbergii*, Japanese Barberry. Park naturalists and scientists are concerned with the possible spread of this woody exotic at Rondeau Provincial Park. This species is generally not preferred by deer due to its spiny thorns, and it may have a competitive advantage over native species in the park.

DATES & LOCATIONS

June-July 1994: Rondeau Provincial Park.

METHODS

Four areas in the park were selected for testing removal methods of *Berberis thunbergii.*, Japanese Barberry. They were Bennett Exclosure, Harrison Trail, South Point Trail and Lakeshore Road. A total of seven sites were chosen from among the four areas (Figure 13):

1) Bennett Exclosure
2) Harrison Trail East
3) Harrison Trail West
4) South Point Trail
5) Lakeshore Road 1
6) Lakeshore Road 2
7) Lakeshore Road 3

At each site four bushes in each of two size categories (n=56), large and small, were selected based on width. Any bush measuring less than 0.4 m wide was classed as small and if greater than 0.4 m wide it was classified as large. Both height and width usually correlated; the larger size class being greater than 0.5 m in height while the smaller class was less than 0.5 m in height.

Each bush was marked with two stakes: one stake 1.5 m to the north side and the other 1 m south. The following measurements were made on each bush:

1) circumference of the largest stem

2) bush width

3) bush height .

One bush in each group of four big or small bushes was randomly assigned to one of four treatments:

1) pulling

2) cutting

3) cutting and spraying with the herbicide, Fencerow (triclortyr 480 g/L; present as butoxyethyl ester)

4) control.

In the pulling treatment, a shovel was used to loosen the dirt and soil around the bush and then the entire bush was pulled out by hand. Efforts were made to pull out the majority of the root system along with each bush. Cutting was done with the assistance of a park warden (A. Miller), who used a disc saw. After cutting, less than 0.5 cm of the bush stems remained above soil level. The cutting and spraying treatment consisted of cutting and direct application of Fencerow to the stems with a sponge brush. The application of the herbicide was delayed for a day (= 30 hrs) due to bad weather conditions. In order for Fencerow to work effectively, there must be no precipitation for 6-8 hours after application. Each stem was thoroughly "painted" with the herbicide.

RESULTS

All bushes will be monitored in 1995 for regrowth. However, shortly after plants had undergone the cutting treatment, regrowth was observed. The plants which underwent pulling and cutting with spraying treatments showed no new growth by the end of the 1994 field season.

7. Patterns of Dispersal in *Alliaria officinalis*, Garlic Mustard at Rondeau Provincial Park

PURPOSE

In order to determine patterns of dispersal and colonization by *Alliaria officinalis*, we studied a) seedling emergence rates within areas already colonized by *A. officinalis* at a range of densities, and b) changes in stem density in relation to nodes of higher density.

DATES & LOCATIONS

July-August 1994: Rondeau Provincial Park.

METHODS

Eighteen sites at Rondeau Provincial Park were selected for this study (Figure 14). Three sites were located near the pony barn while the remaining 15 were located on two transects along Lakeshore Drive. These studies were set up from from July 20 to August 3, 1994, and will culminate in 1995.

A) Seedling emergence rates in relation to density of *A. officinalis*

At each of the 18 sites, trays of sterile soil (50 cm x 25 cm) were placed within a patch of *A. officinalis* . Three concentric circles with radii of 1 m, 5 m, and 10 m were marked out around the tray. Each of these circles were divided into four quadrants (northeast, northwest, southeast, southwest) forming twelve sub-sections within the 10 m radius circle (Figure 15a). The number of plants in each sub-section was counted, and the density of *A. officinalis* was calculated.

B) Changes in stem density

In order to look at the rate at which plants spread, 18 patches of *A. officinalis* with a minimum size of 2 m x 2 m were marked in the vicinity of the trays. The maximum length and width of these patches were measured, and the number of plants within these patches was counted. A border marked by flags was established in each of these patches separating regions which varied in *A. officinalis* density by a ratio of at least 6 to 1 (Figure 15b).

RESULTS

A) Seedling emergence rates

In May 1995, the number of *A. officinalis* seedlings in each tray will be counted. A multiple regression will examine the relationship between the density

of *A. officinalis* in the quadrants in 1994 and the number of seedlings in the trays. This will determine if there is a directional effect in the spread of *A. officinalis* through the park.

B) Changes in stem density

In May 1995, the size of the patches and the density of *A. officinalis* on both sides of these borders will be remeasured. This should indicate the rate at which *A. officinalis* is spreading through the park.

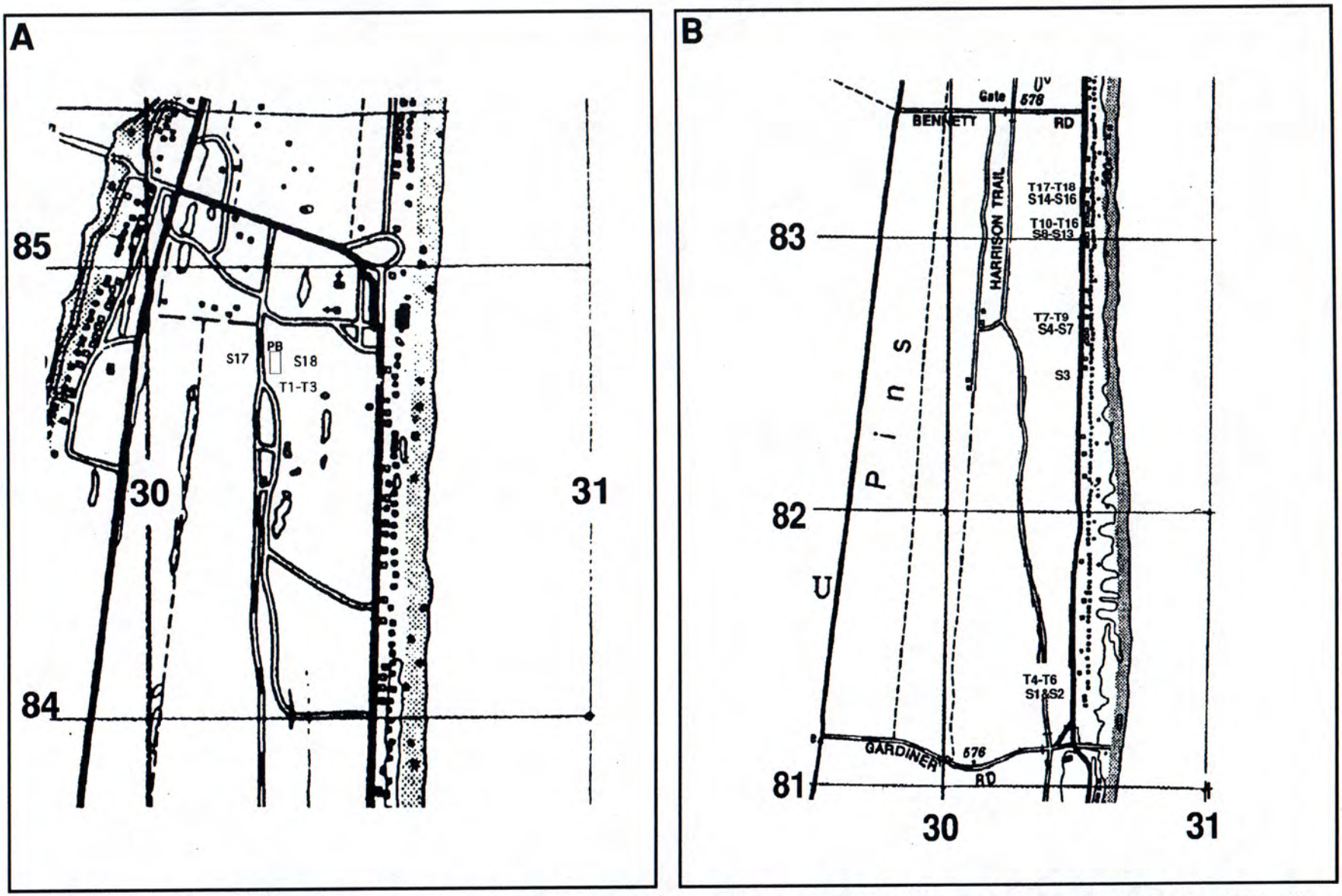


Figure 14. Location of sites where change in plant density and seedling emergence was investigated for *Alliaria officinalis* at Rondeau Provincial Park. A) Sites located around the Poney Barn (PB); B) Sites located between Bennett and Gardiner Roads. S = patches flagged to quantify changes in stem density; T = patches flagged to quantify seedling colonization of trays of sterile soil.

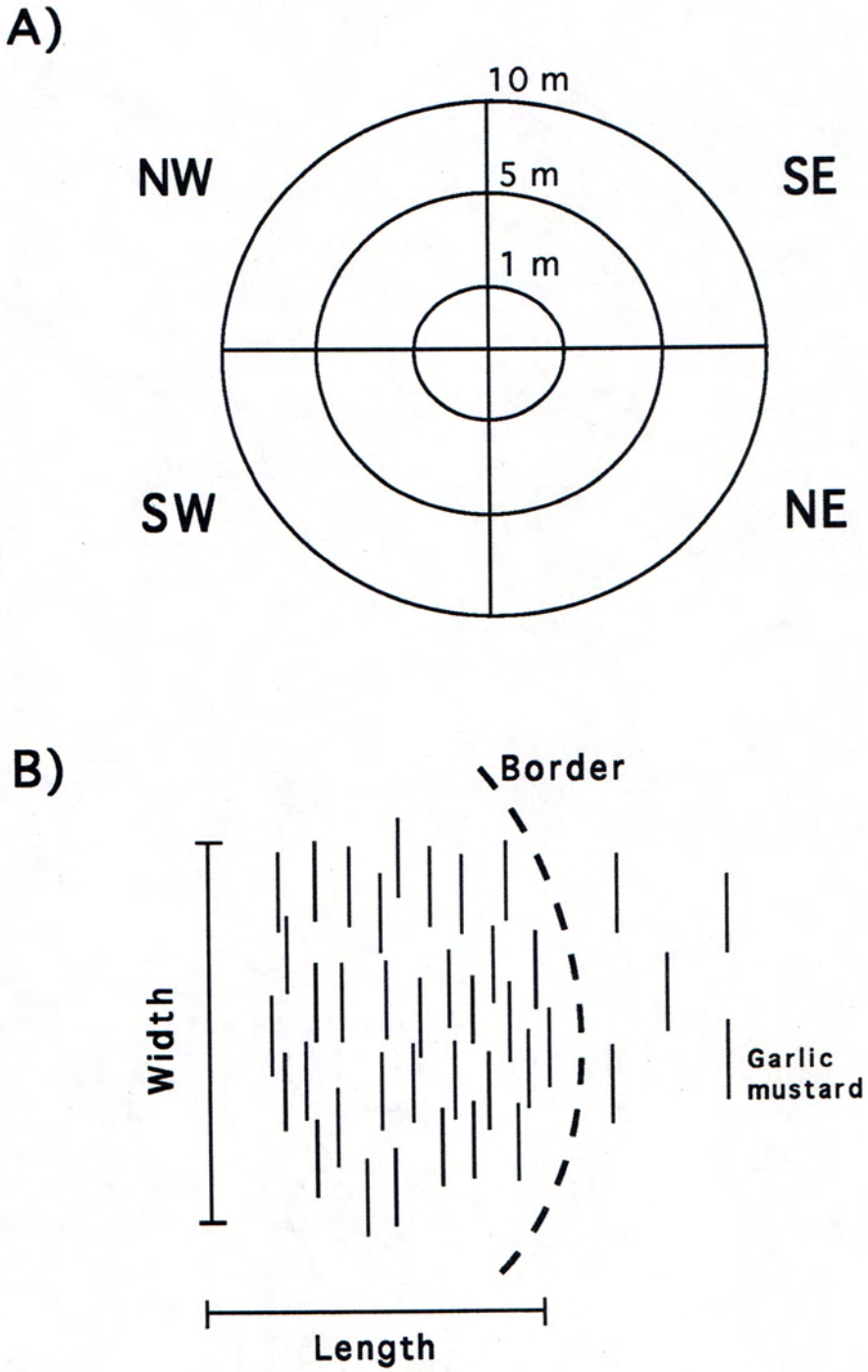


Figure 15. The layout of plots to study a) seedling emergence rates and b) changes in stem density in relation to nodes of higher density of garlic mustard.

8. Survey of Woody Vegetation

PURPOSE

Surveys of the woody plant community were carried out at Rondeau and Pinery Provincial Park to determine the species composition and the size distribution of woody plants prior to deer herd reductions.

DATES & LOCATIONS

July-August 1993: Rondeau Provincial Park.
July-September 1994: Pinery Provincial Park.

METHODS

At Rondeau and Pinery Provincial Parks, we surveyed the trees and shrubs at the same sites used for monitoring herbaceous plant communities in each of the parks' habitat types (Section 2). The protocol was adapted from the bird and vegetation survey conducted in Rondeau Provincial Park in 1991 (Bowles & Gartshore, 1992; Gartshore, 1994).

At each of these sites a 20 m transect (north-south) bisected by a 10 m transect (east-west) was established. These transects were centred at the grazed plot of each site except at Rondeau's Gardiner and Bennett sites. At the latter two sites, five stations were randomly chosen from inside and outside the exclosures. The four terminal points and the point at which the transects intersected were marked (Figure 16). At each of these five points (four points were used at the Bennett and Gardiner sites due to the proximity of the fence line) we measured basal area, crown closure, and the distance (metres) to the nearest tree and shrub. From this tree and shrub the distance to the nearest neighbour (tree or shrub) was measured. From this "nearest neighbour" the distance to the next "nearest neighbour" tree or shrub was measured (Figure 16). This method allowed us to sample each site using both a "closest individual" protocol (Figure 16; distance 1 - d_1) and a "nearest neighbour" protocol (Figure 16; distances 2 and 3 - d_2 and d_3) (Mueller-Dombois & Ellenberg, 1974). We recorded the species of the trees and shrubs encountered and their diameter at breast height (cm). At each plot 15 individuals (12 at Bennett and Gardiner) were measured in each of the tree and shrub categories.

We defined trees as live woody stems with diameters greater than 7.5 cm at 1.4 m above the ground or in the case of fallen live trees 1.4 m from where the

ground would have been if the tree was still standing. We defined shrubs as woody stems that were taller than 0.4 m with a diameter of less than 7.5 cm at 0.4 m from ground level. We did not include dead trees and shrubs.

RESULTS

In 1998 (year 5 of the project), the woody vegetation at Pinery and Rondeau will be resampled to determine the changes in the woody community. Presently, S. Koh and D. Bazely are analyzing the data, and examining differences in the woody communities between the habitat types of the two parks.

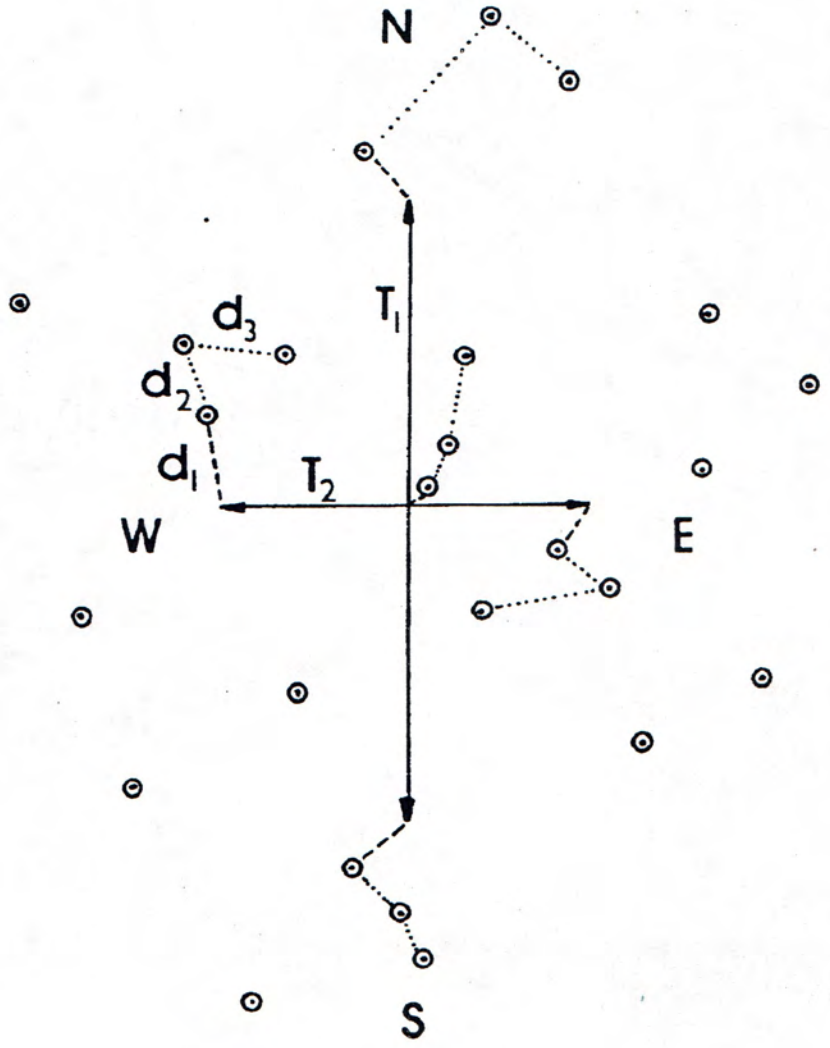


Figure 16. Sampling scheme for woody species. A single sample station or plot is illustrated in which two transects (T1=20 m, T2=10 m) bisect each other. The nearest tree and distance (d1) to the end of each transect and the point at which the transects intersected was measured. The distance to the nearest tree (d2) from the first tree was also measured in addition to the distance to the next nearest neighbour (d3).

9. Survey of Available Woody Browse at Pinery and Rondeau Provincial Parks

PURPOSE

These surveys will allow us to estimate the amount of woody browse available for deer. Each year of the project this procedure will be repeated at Pinery and Rondeau Provincial Parks. This will allow us to examine change in woody browse available to the deer over time and to compare the parks. This will provide another indicator of habitat recovery following intense grazing pressure. Estimates of the proportion of the current annual growth eaten by deer will also permit the evaluation of the present carrying capacity of the Rondeau and Pinery deer herds.

DATES & LOCATIONS

October-December 1994: Pinery and Rondeau Provincial Parks.

METHODS

From October to December 1994, the biomass of woody browse was sampled from 58 plots at Pinery Provincial Park and 12 plots at Rondeau Provincial Park. At Rondeau, four plots were randomly selected in each habitat type (dry, mesic, and wet); the plots at Pinery were selected from among the park's six representative habitat types. The centre of each plot corresponded to the grazed plots in herbaceous plant community study at Rondeau (1991 sites) and Pinery. At this centre, a 40 m north/south transect bisecting a 20 m east/west transcect was established. At the ends of the transects and at the centre of the site, 3.2 m X 3.2 m quadrats were marked (five in total; Figure 17).

At each quadrat, the number of stems between 0-50 cm and 50-200 cm in height that were producing current annual growth were tallied (by species for the 50-200 cm height class). Inside each quadrat, three stems (50-200 cm) nearest to the corners of the quadrat were selected for estimating available woody biomass. If a stem could not be found in a quadrat, the nearest stem to the quadrat was sampled. The current annual growth was clipped from these stems and placed in a bag. These samples are currently being weighed.

RESULTS

The report for the 1995 field season will provide the first analyses of these data.

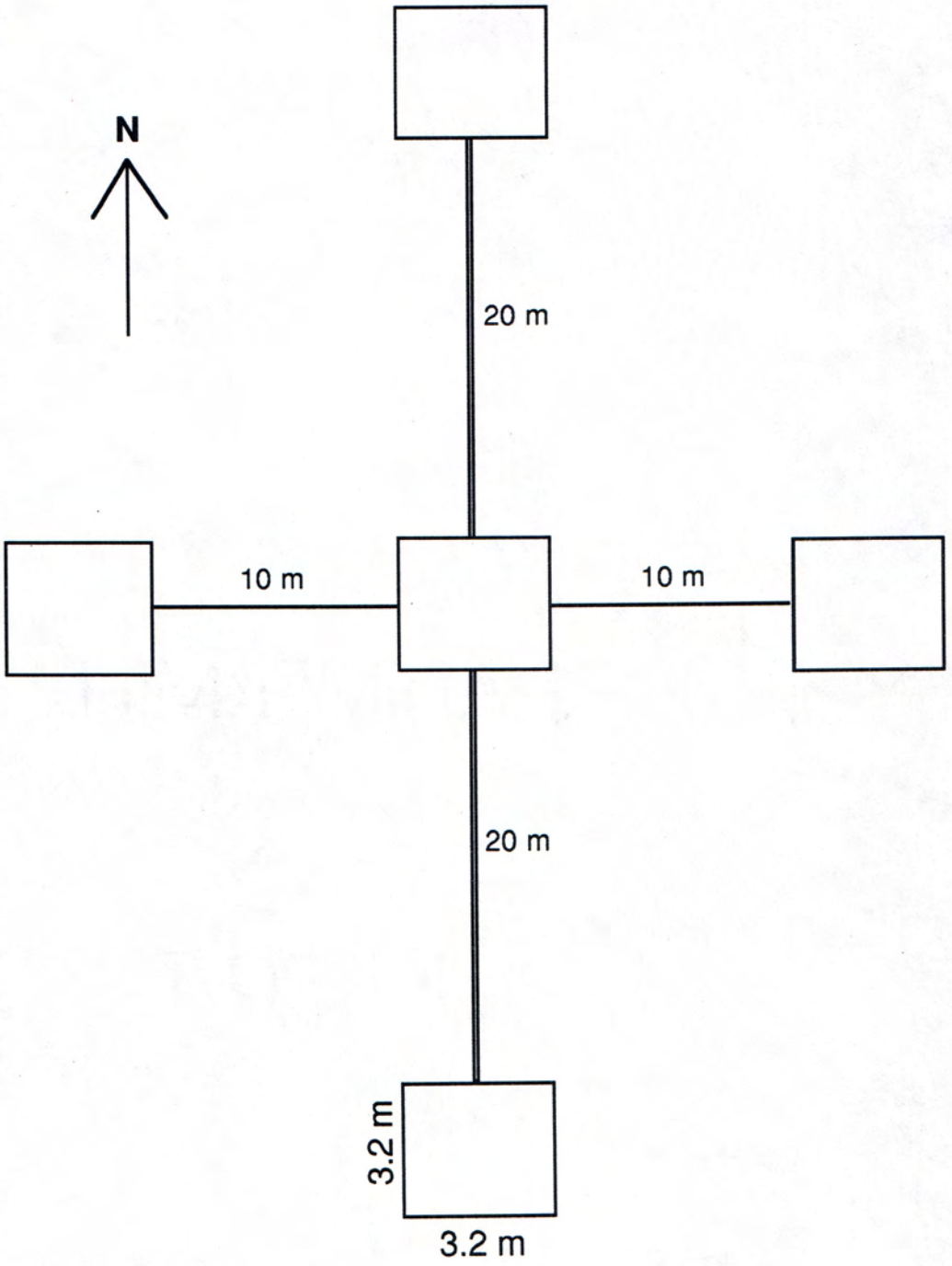


Figure 17. The arrangement of plots for the assessment of woody browse available to the deer.

10. References

Alexander, K.I, and K. Thompson. 1982. The effect of clipping on the competitive interaction between two perennial grass species. Oecologia, 53: 251-254.

Anderson, P., and E. Radford. 1994. Changes in vegetation following reduction in grazing pressure on the National Trust's Kinder Estate, Peak District, Derbyshire, England. Biological Conservation, 69: 55-63.

Argus, G.W., K.M. Pryer, D.J. White, and C.J. Keddy. 1982-1987. Atlas of the Rare Vascular Plants of Ontario. National Museum of Natural Sciences, Ottawa.

Bakowsky, W.D. 1990. The vegetation of Pinery Provincial Park. Ontario Ministry of Natural Resources, Internal Report.

Bergelson, J. 1990. Spatial patterning in plants: opposing effects of herbivory and competition. Journal of Ecology, 78: 937-948.

Bowles, J.M., and M.E. Gartshore. 1992. Monitoring the response of vegetation and breeding bird communities to a reduction in deer browsing at Rondeau Provincial Park: baseline survey 1991. Ontario Ministry of Natural Resources, Internal Report.

Brandner, T.A., R.O. Peterson, and K.L. Risenhoover. 1990. Balsam fir on Isle Royale: effects of moose herbivory and population density. Ecology, 71: 155-164.

Brown, J.R., and J.W. Stuth. 1993. How herbivory affects grazing tolerant and sensitive grasses in a central Texas grassland: integrating plant response across hierarchical levels. Oikos, 67: 291-298.

Clay, K., S. Marks, and G.P. Cheplick. 1993. Effects of insect herbivory and fungal endophyte infection on competitive interactions among grasses. Ecology, 74: 1767-1777.

Crawley, M.J. 1983. Herbivory: the dynamics of animal-plant interactions. University of California Press, Los Angeles.

Fridd, V. 1994. "Why is Garlic Mustard such as successful invader of Carolinian Forests in Southern Ontario?" B.Sc. Thesis, Guelph University.

Gartshore, M.E. 1994. Monitoring the response of breeding bird communities to a reduction in deer browsing at Rondeau Provincial Park: baseline survey 1993. Ontario Ministry of Natural Resources, Internal Report.

Grace, J.B. & D. Tilman. 1990. Perspectives on plant competition. Academic Press, Toronto.

Koh, S. 1991. The effect of grazing by white-tailed deer *Odocoileus virginianus* on herbaceous plant species composition and cover in Rondeau Provincial Park. Ontario Ministry of Natural Resources, Internal Report.

Koh, S. 1992. Response of vegetation to grazing pressure by white-tailed deer *Odocoileus virginianus.* Point Pelée National Park, Internal Report.

Koh, S. 1994. Responses of vegetation to grazing by white-tailed deer *Odocoileus virginianus.* Point Pelée National Park, Internal Report.

Koh, S., D.R. Bazely, and D.R. Voigt. 1994. Responses of spring-flowering herbs to grazing by white-tailed deer *Odocoileus virginianus* . I. *Trillium grandiflorum* (Michx.) Salisb. Canadian Journal of Botany, accepted subject to revision.

Landplan Collaborative Ltd. 1990. The effects of browsing and trampling by white-tailed deer on Pinery Provincial Park and its environments. Canadian Parks Service, Internal Report.

Landplan Collaborative Ltd. 1991. Vegetation management objectives, Point Pelée National Park. Canadian Parks Service, Internal Report.

Louda, S.M. 1984. Herbivore effect on stature, fruiting, and leaf dynamics of native crucifer. Ecology, 65: 1379-1386.

McCullough, G.B., and J. Robinson. 1988. Overbrowsing of vegetation by white-tailed deer on the Long Point National Wildlife Area. Canadian Wildlife Service, Internal Report.

McNaughton, S.J. 1979. Grassland-herbivore dynamics. In Serengeti: Dynamics of an Ecosystem (Eds. A.R.E. Sinclaire and M. Norton-Griffiths). University of Chicago Press, Chicago.

Mueller-Dombois, D., and H. Ellenberg. 1974. Aims and methods of vegetation ecology. John Wiley & Dons, New York.

Newcomb, Lawrence. 1977. Newcomb's Wildflower Guide. Little, Brown Company, Toronto.

Rockwood, L.L., and M.B. Lobstein. 1994. The effects of experimental defoliation on reproduction in four species of herbaceous perennials from northern Virginia. Castanea, 59: 41-50.

Shimoda, K., K. Kimura, M. Kanzaki, and K. Yoda. 1994. The regeneration of pioneer tree species under browsing pressure of Sika deer in an evergreen oak forest. Ecological Research, 9: 85-92.

Stuart-Hill, G.C. 1992. Effects of elephants and goats on the Kaffrarian succulent thicket of the eastern Cape, South Africa. Journal of Applied Ecology, 29: 699-710.

Varga, S., and G.M. Allen. 1990. County/regional municipality vascular plant floras for the Carolinian zone of Canada. In Conserving Carolinian Canada (Eds. G.M. Allen, P.F.J. Eagles, and S.D. Price. University of Waterloo Press, Waterloo.

Watkinson, A.R. 1988. Plant Population Dynamics. In Plant Ecology (Ed. M.J. Crawley). Blackwell Scientific Publications, Oxford.

Yaraskavitch, K.M. 1983. The effects of deer browsing on forest succession in Rondeau Provincial Park. Ontario Ministry of Natural Resources, Internal Report.

Appendix A
Computer Databases and Digitized Maps

Using a Power Macintosh 7100 computer, we created the following databases with Excel software:

1) The 1992 percent cover and frequency data of the herbaceous communities is almost 9 MB in size. This huge database is unique in that it covers several locations across southern Ontario with multiple sampling dates throughout a single growing season.

2) The 1994 percent cover and frequency data of the herbaceous communities of Rondeau and Pinery Provincial Parks covers the representative habitat types of these parks (752 kB). A similar database has been created for Rondeau Provincial Park in 1991, and will soon be available in an Excel format.

3) The 1994 indicator species data contains the heights of several species under different grazing regimes in the representative habitat types of Rondeau Provincial Park (171 kB).

4) Similar computer databases are being constructed with the woody survey data collected by S. Koh, D. Bazely, and D. Voigt (1993-1994; Table 2).

These databases can be acquired from Dr. D. Bazely at York University's Department of Biology. They are available in Excel and Text formats for PC and Macintosh computers.

Using an Apple OneScanner available in the Department of Biology at York University, we digitized UTM maps of Rondeau and Pinery Provincial Parks. These files are available in Canvas and Pict formats for Macintosh computers.