Response of Vegetation to Grazing Pressure by White-Tailed Deer *Odocoileus virginianus*

Progress report on studies carried out in1992 at Point Pelée and at other sites in Southern Ontario

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1. INTRODUCTION

Grazing by large mobile mammalian herbivores can have a great impact on plant communities (Huntly 1991, Crawley 1988). Many studies have documented the shifts in plant species composition and diversity, in the age structure of plant populations, and in live biomass levels in response to grazing by herbivores such as white-tailed deer (*Odocoileus virginianus*) (Putman et al 1989, Stewart and Burrows 1989, Whitney 1990, Connor and Pickett 1992, Gibson and Brown 1992). Deer can also affect individual plants as demonstrated by Allison (1990) who showed that browsing reduced pollen production in Canada yew (*Taxus canadensis*).

The recent rapid increase in the population of white-tailed deer may be a threat to some plants in southern Ontario's Carolinian ecosystem. The relatively warm climate and long growing season of some sites in southern Ontario permit a northward range extension of some plant species normally found further south. Seventy percent of Ontario's rare plant species are exclusive to the Carolinian zone (Varga and Allan 1990).

White-tailed deer have had a negative impact on Point Pelée National Park and other key Carolinian sites such as Pinery Provincial Park, Rondeau Provincial Park and Long Point National Wildlife Area, where severe browsing over many years has prevented seedlings of many tree species from growing beyond the sapling height class (McCullough and Robinson 1988, Landplan 1990, Landplan 1991, Yaraskavitch 1983). Changes in woody species composition at these sites are may have been caused by the selective browsing behaviour of deer (Yaraskavitch 1983, Landplan 1991).

In order to respond adequately to increased public awareness of the importance of evaluating and maintaining biodiversity in Ontario's ecosystems, we need to know how herbivory influences herbaceous as well as woody plants. There is a tendency for both ecologists and members of the public to think of deer as browsers, feeding primarily on woody species, i.e., those that produce secondary growth. However deer also forage heavily on herbaceous and graminoid plant species. Unfortunately, there is little information available on the impact of grazing by white-tailed deer on these plants.

Recent studies at Rondeau found that (herbaceous) plant community composition in large exclosures, inaccessible to deer since 1978, was significantly different from that of heavily grazed control areas. The grazed sites were dominated by graminoids, *Galium* spp. and *Urtica* spp., while *Trillium* spp., *Arisaema triphyllum*, and *Podophyllum pelatum* were abundant inside the exclosures (Koh 1991a). Spring flowering perennials (*Trillium spp.* and *A. triphyllum*) growing inside the large exclosures were taller and had higher rates of flower production than plants growing in areas accessible to deer (Koh 1991b). It has also been reported that some species (*T. grandiflorum* and *Liatris cylandracea*) believed not to occur at Long Point were found only one year after the deer herd was culled (Landplan 1991). Plots in Rondeau exclosed from deer since 1991 showed increased biomass production by 1992, one year later, but the overall species richness did not increase (unpubl. data Koh 1992).

Since deer may be "overgrazing" various sites in southern Ontario, and are clearly influencing plant species richness and abundance at some sites, it is of paramount importance to determine how individual species respond to herbivory. This is because changes observed at the plant community level are underlain by changes at the level of the component species.

In addition, information on plant response to herbivory will be important in helping to determine the range of deer population levels that will not result in loss of species from communities. In the past, decisions to cull deer populations in some sites have been undertaken when chronic overgrazing appears to have occurred. It is desirable to take action at an earlier stage.

The overall objective of this study was to determine how plant communities at Point Pelée National Park respond to grazing by deer. This research formed one component of wider-ranging study that examined vegetation responses to herbivory in ten other southern Ontario sites with varying deer population numbers (Figure 1). Where appropriate, in this report the results from Point Pelée are set in the context of results from the other sites. The Hillman Sand Hills site, near Point Pelée, was used as a "control" site, since there are apparently few deer here, and grazing pressure is low. In addition to investigating growth of plant species in the presence and absence of herbivory, potential for recovery from overgrazing was evaluated in a seed bank study. The results are not presented in this report but will be available in Saewan Koh's M.Sc. thesis.

Specific objectives in this report are:

(1) To determine the impact of grazing by deer on seasonal trends in the composition and cover of herbaceous plant species.

(2) To determine the usefulness of plant species composition and cover as an indicator of deer grazing pressure.

(3) To determine the impact of grazing by white-tailed deer on the growth and demography of *T. grandiflorum*. *T. grandiflorum* is widespread throughout southern Ontario, and may be a useful "baseline" species in evaluating the impact of deer herbivory.

(4) To determine the usefulness of *T. grandiflorum* as an indicator species of deer grazing pressure.

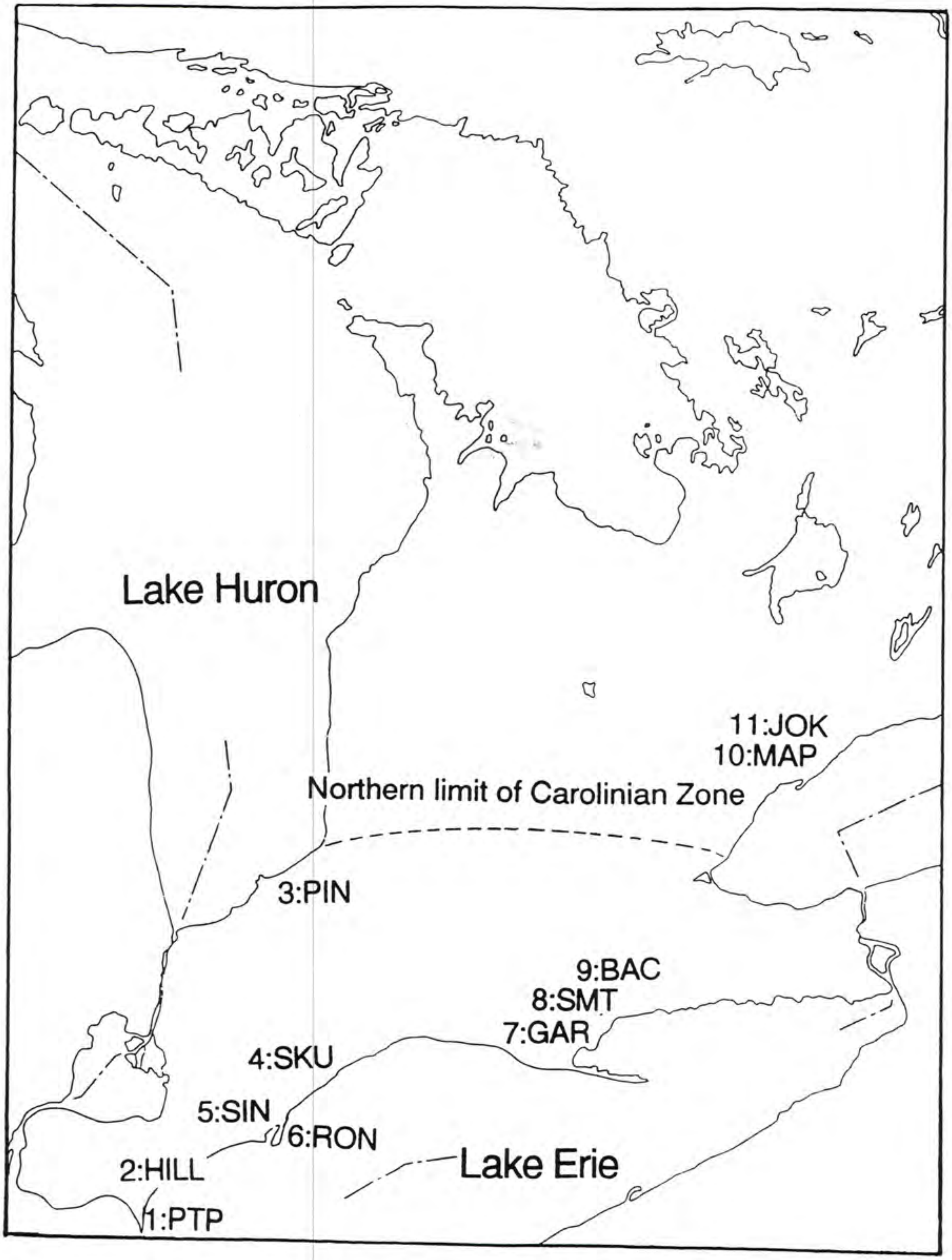

Figure 1. Location of study sites in southern Ontario

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 Tract, 8) Smith Tract, 9) Backus Woods, 10) Maple, 11) Joker's Hill

All sites, with the exception of Maple and Joker's Hill, are in the Carolinian zone.

2. METHODS

2.1 Site Selection

2.1.1 Point Pelée National Park

In the first week of March 1992 we plotted one 1 km transect in both the northern and southern hardwood dominated sections of Point Pelée National Park (Figure 1). We randomly selected four locations from among the 100 m points along the northern transect, and six locations at the 100 m points along the southern transect, which gave a total of ten sites. At each site we built one 1 m x 1 m x 1 m chicken wire exclosure and marked out one 1 m x 1 m control plot 3 m away from the exclosure on a random compass bearing.

2.1.2 Hillman Sand Hills

In the first week of March, at Hillman Sand Hills (Figure 1), we randomly selected a total of ten sites from four 300m transects and at each site we built a 1 m x 1 m x 1 m exclosure and marked out a 1 m x 1 m control plot 3 m from the exclosure in a random compass bearing direction.

2.2 Surveys of Vegetation Carried Out in 1992

2.2.1 Plant Cover and Species Composition

We scored the exclosures and control plots for the number and percentage cover of plant species at Point Pelée and Hillman on May 6, June 6, July 10 and August 24,1992.

2.2.2 Above-ground Biomass of Herbaceous and Woody Vegetation

A 1 m x 1 m plot was randomly selected 5 m away from each exclosure in a random compass direction at Point Pelée and Hillman. At the end of May and August all of the live herbaceous above-ground biomass and new above-ground growth on woody plants in these plots was clipped, dried to constant weight at 60° C and weighed.

2.2.3 Growth and Demography of *T. grandiflorum* at Point Pelée, Hillman Sand Hills and Ten Other Southern Ontario Sites.

In early April we randomly selected and tagged 40 *T. grandiflorum* plants at Hillman. At each of the other southern Ontario sites except Rondeau Provincial Park (Figure 1) we marked approximately 40 *T. grandiflorum* plants. None of these *T. grandiflorum* were in exclosures. At Rondeau we randomly selected and tagged 25 *T. grandiflorum* in each of the two large exclosures built in 1978 and we randomly selected and tagged 40 *T. grandiflorum* growing inside eleven 2 m x 2 m exclosures built in 1991. Seventy *T. grandiflorum* were marked in control plots, exposed to deer, near the 2 m x 2 m exclosures. We found no *T. grandiflorum* at Point Pelée.

From early May to early June we measured all plants for their height, leaf length and flower production. Herbivory damage was also recorded. In the third week of May we made paper traces of leaves and measured their leaf area index with a Hicor leaf area meter.

2.2.4 Preliminary Statistical Analysis

Repeated measures ANOVAs showed that plant species richness, vegetation cover and above-ground biomass did not differ between exclosed and grazed sites at either Hillman or Point Pelée in 1992. Spearman Rank Correlation Coefficient Analysis showed that, over the same period, exclosures did not have a significant effect on plant species composition and dominance hierarchy (Sokal and Rohlf 1981). Therefore data from exclosed and grazed sites were pooled within both Point Pelée and Hillman for all further statistical analyses.

3. RESULTS

3.1 Vegetation Cover

Seasonal trends in mean percentage vegetation cover at Hillman and Point Pelée are shown in Figure 2. Percentage cover was lower at Hillman than at Point Pelée from May to August. Mean percentage cover at Hillman decreased from 33% on May 6 to 17% by August 24. The mean percentage cover at Point Pelée increased from 56% on May 6 to the season peak of 111% on June 6 (Figure 2). It subsequently declined.

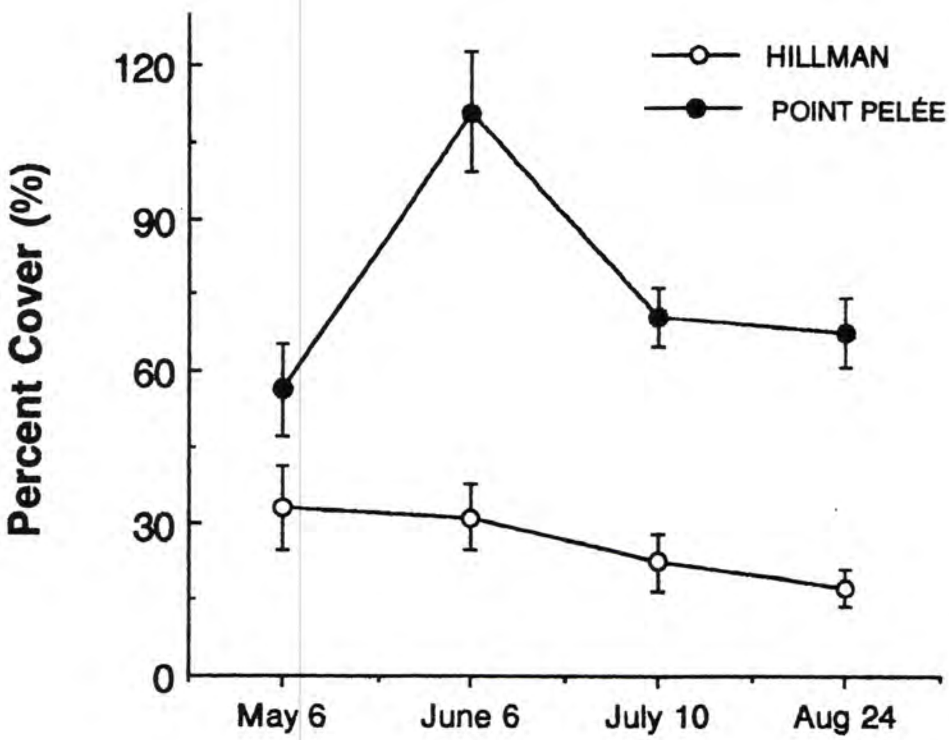

Figure 2. Seasonal trends in percentage vegetation cover at plots at Point Pelée and Hillman (Mean ± standard error; n = 20 for each date and site).

3.2 Plant Species Richness

The total number of plant species, generic groups (which could not be identified to species) and unidentified woody species (occurring as seedlings) found over the course of the summer did not vary greatly between or within Point Pelée and Hillman Sand Hills (Figure 3). (See Table 2 for list of plant categories.) At Hillman, exclosed plots contained 35 different plant categories compared to 30 in the control (grazed) plots. A total of 35 plant groups were identified at Hillman. At Point Pelée from a total of 36 different plant categories, 33 and 32 respectively were scored in the exclosed and control plots respectively. Overall a total of 22 plant groupings were common in both sites: 14 were exclusive to Point Pelée and 13 to Hillman.

3.3 Density of Plant Species

The mean number of plant species m^{-2} at Hillman Sand Hills was significantly lower than at Point Pelée on three out of the four sampling dates (Figure 4). On May 6 there was 2.7 plant species m^{-2} at Hillman compared with 4.8 species at Point Pelée. From June 6 to July 10 the number of plant species m^{-2} at Hillman did not vary while over the same period the number of species, dropped from 7 to 6 at Point Pelée (Figure 4). On the last sample date, August 24, the mean number of plant species m^{-2} at Hillman, 4.4, was not significantly different from the mean number of 4.6 at Point Pelée (Figure 4).

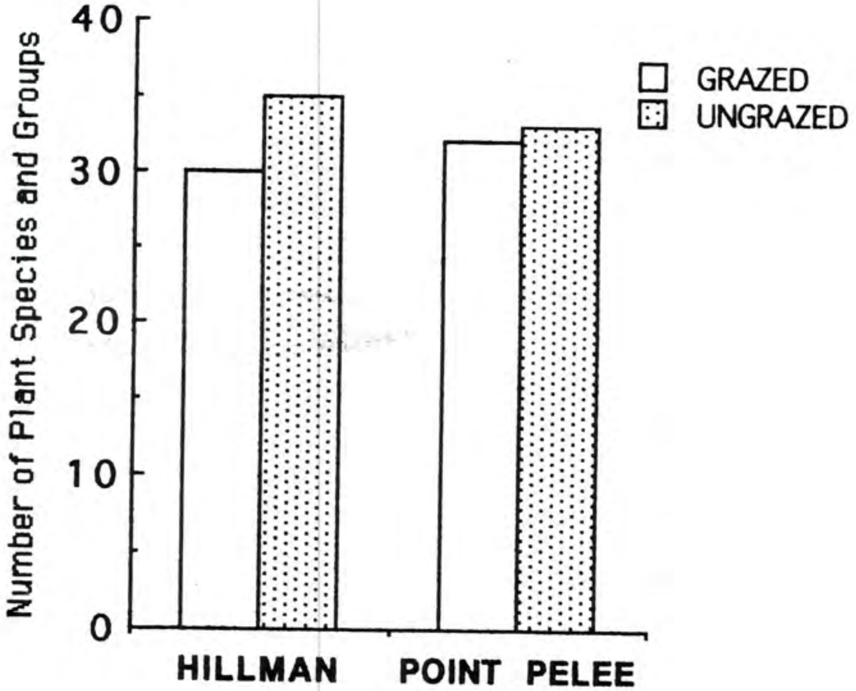

Figure 3. Total number of plant species and pooled groups (e.g., unidentified woody species) at Point Pelée and Hillman Sand Hills in 1992.

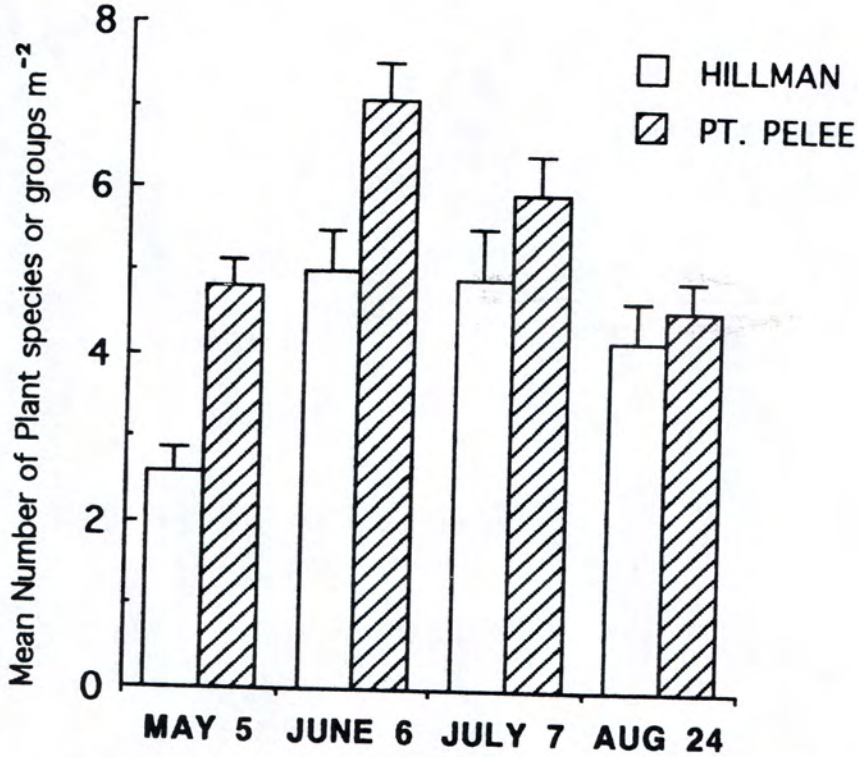

Figure 4. Seasonal trends in mean number of herbaceous plant species m^{-2} at Point Pelée and Hillman (Mean ± Standard error; n = 20).

These simplified data indicate that there are differences in plant community composition between Point Pelée and Hillman.

In order to investigate these differences, two further analyses were carried out:

(1) An examination of the relative abundance of different species in terms of numbers of individuals.

(2) An examination of the relative abundance of different species in terms of percent cover.

3.4 Relative Abundance of Numbers of Individuals of Different Plant Species.

A conservative estimate of the number of shoots produced by each species during the season was made by totaling the number of shoots (individuals) of each species present in all plots in each site on the first sample date. Any new individuals present on subsequent sample dates were added to this total. In order to qualify as "new", a shoot had to fulfill either of two conditions:

(1) It had to be growing in a plot in which no shoot had previously been recorded

or

(2) If it was in a plot for which there was a previous record of that species, then the number of shoots had to have increased, e. g., if there was one *T. grandiflorum* plant present in plot 1 on dates 1 and 2 then it was counted as only one plant. However if there was one plant present on date 1 and two plants present on date 2, then an increase in the number of individuals by one was recorded.

This method assumes no turnover (death) of individuals during the season, and may lead to underestimates of the number of individuals of a species.

Following these tabulations, species for which more than three individuals were scored among all sites, were compared between Hillman and Point Pelée. Species which were twice as abundant at Hillman compared with Point Pelée were identified and *vice versa*.

Table 1a lists 16 herbaceous species and genera which were more abundant at Point Pelée (recovering from heavy grazing) compared with Hillman (light to moderately grazed). Table 1b indicates species and genera which were more abundant at Hillman compared with Point Pelée.

In both tables species or genera which were more abundant in either the grazed or ungrazed sites at Rondeau Provincial Park (based on data gathered in the summer of 1991, Koh 1991a) are asterisked. The 5 species that were more abundant in the grazed Rondeau sites appear in the Point Pelée list (Table 1a). Of the 8 herbaceous plant species that were more abundant in the ungrazed sites at Rondeau, 6 appear in the Hillman list (Table 1b). Table 1c lists all of the species of similar abundance at both Point Pelée and Hillman.

3.5 Plant Species Abundance as Percent Cover

Table 2 shows maximum percent cover for species and genera at Point Pelée and Hillman. The values given are based on the maximum percent cover for each species in each plot during the growing season. The mean of these values was taken for n = 20 pooled grazed and ungrazed sites at Point Pelée and Hillman respectively. A Spearman Rank Correlation Coefficient analysis revealed a significant difference ($p = 0.2094$) between sites (Table 2). This difference in abundance is further illustrated by Figure 5. Plants mostly occur at Point Pelée or Hillman but not usually at both sites.

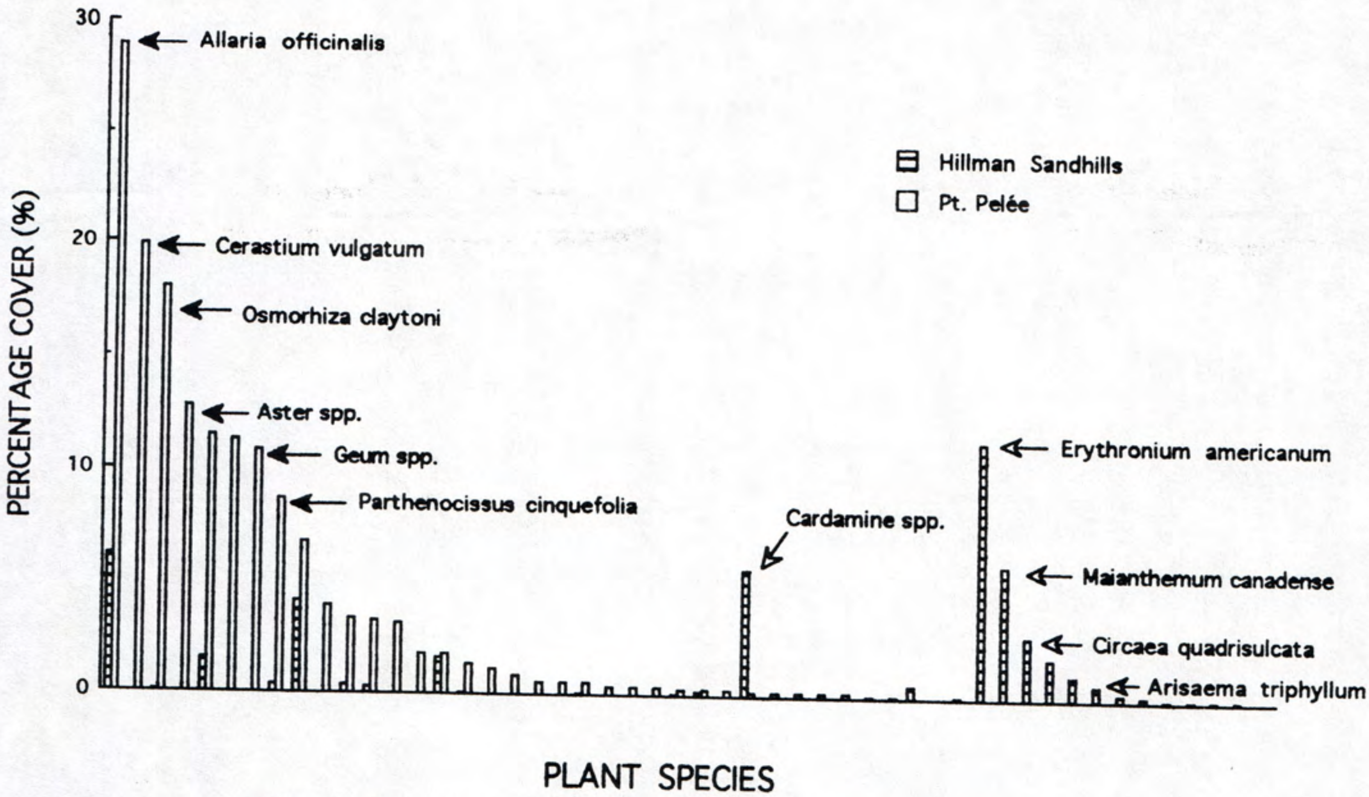

Figure 5. Abundances of herbaceous plant species expressed as maximum percent cover

Table 1a. Plant species that were more abundant at Pt. Pelée than at Hillman Sand hills. Species are listed in descending order of abundance found at Pt. Pelée.

Plant species	No. of Individuals Pt. Pelée	Hillman
Geum aleppicum/canadense/laciniatum	58	9
*Osmorhiza claytoni**	43	6
Geranium robertianum	42	13
*Polygonatum biflorum/pubescens**	28	11
Cerastium vulgatum	25	1
Phryma leptostachya	22	9
Aster spp.	21	2
Pilea pumila	15	0
*Galium circaezans/triflorum** *	15	1
Solidago spp.**	12	5
Rubus idaeus/allegheniensis	11	4
Graminoids**	9	2
Viola spp.**	7	0
Urtica spp.**	4	0
Smilax tamnoides	5	0
Dicentra cucullaria	3	0

* Plant species that were more abundant in ungrazed exclosures over heavily grazed control plots at Rondeau Provincial Park in 1991 (Koh 1991a).

** Plant species that were more abundant in heavily grazed control plots over ungrazed exclosed plots at Rondeau Provincial Park in 1991 (Koh 1991a).

Table 1b. Plant species that were more abundant at Hillman Sand Hills than at Point Pelée. Species are listed in descending order of abundance found at Hillman.

	No. of Individuals	
	Hillman	Pt. Pelée
Plant species		
Maianthemum canadense *	31	0
Circaea quadrisulcata	22	0
Thalictrum dioicum *	21	0
Arisaema triphyllum *	15	0
Erythronium americanum	12	0
Podophyllum peltatum *	17	6
Rhus radicans	10	1
Geranium maculatum *	4	0
Trillium grandiflorum *	3	0

* Plant species that were more abundant in ungrazed exclosures (erected in 1978) compared with heavily grazed control plots at Rondeau Provincial Park in 1991
(Koh 1991a).

** Plant species that were more abundant in heavily grazed control plots over ungrazed exclosed plots at Rondeau Provincial Park in 1991 (Koh 1991a).

Table 1c. Plant species found in equal abundance at Hillman Sand Hills and Point Pelée. Frequencies are for each species over the entire season at each site.

	No. of Individuals	
	Hillman	Pt. Pelée
Plant species		
Allaria officinalis	38	59
Parthenocissus cinquefolia	29	20
Vitis aestivalis	3	3
Polygonum spp.	3	3
Aquilegia canadensis	3	2

Table 1c. Plant species found in equal abundance at Hillman Sand Hills and Point Pelée. Frequencies are for each species over the entire season at each site.

	No. of Individuals	
	Hillman	Pt. Pelée
Plant species		
Allaria officinalis	38	59
Parthenocissus cinquefolia	29	20
Vitis aestivalis	3	3
Polygonum spp.	3	3
Aquilegia canadensis	3	2

Table 2. Maximum percent cover of plant species at Point Pelée and Hillman Sand Hills (values are means of maximum value for each plot recorded during the season; n = 20). Species are listed in the descending order of cover found at Pt. Pelée.

	Maximum Percentage Cover	
	Pt. Pelée	Hillman
PLANT SPECIES		
Allaria officinalis	29.00	6.12
Cerastium vulgatum	19.95	0.00
Osmorhiza claytoni	18.08	0.05
Aster spp.	12.80	0.04
Geranium robertianum	11.50	1.55
Urtica spp.	11.25	0.00
Geum spp.	10.80	0.00
Phryma leptostachya	8.60	0.38
Parthenocissus quinquefolia	6.70	4.12
Rubus spp.	3.85	0.03
Solidago spp.	3.30	0.40
Polygonatum biflorum/pubescens	3.28	0.32
Polygonum pensylvanicum	3.10	0.00
Galium spp.	1.80	0.04
unidentified Woody species	1.79	1.58
Pyrola spp.	1.31	0.08
graminoids	1.15	0.05
Dicentra cucullaria	0.85	0.00
Hydrophyllum macrophyllum	0.60	0.00
Smilax tamnoides	0.56	0.00
Tovara virginiana	0.55	0.12
Viburnum acerifolium	0.40	0.01
Carpinus spp.	0.36	0.00
Polygonum scandens	0.35	0.02
Vitis spp.	0.32	0.05
Aquilegia canadensis	0.25	0.15
Viola spp.	0.24	0.00
Cardamine douglassii	0.20	5.64
Smilax rotundifolia	0.20	0.00
Pilea pumila	0.15	0.00

Table 2 Cont. Maximum percent cover of plant species at Point Pelée and Hillman Sand Hills Species are listed in the descending order of cover found at Pt. Pelée.

	Maximum Percentage Cover	
	Pt. Pelée	Hillman
PLANT SPECIES		
Amphicarpa bracteata	0.15	0.00
Smilacina racemosa	0.10	0.00
Ribes spp.	0.06	0.00
Fraxinus spp.	0.02	0.57
Ranunculus abortivus	0.02	0.01
Rhus radicans	0.01	0.09
Agrimony rostellata	0.00	11.38
Arisaema triphyllum	0.00	5.88
Circaea quadrisulcata	0.00	2.75
Maianthemum canadense	0.00	1.77
Acer spp.	0.00	1.01
Thalictrum dioicum	0.00	0.69
Sassafras albidum	0.00	0.30
Claytonia virginica/caroliniana	0.00	0.17
Trillium spp.	0.00	0.13
Erythronium americanum	0.00	0.12
Lilium spp.	0.00	0.09
Anemone quinquefolia	0.00	0.08
Dyopteris cristata	0.00	0.01

3.6 Live Above-ground Biomass of Herbaceous and Woody Plant Species

Mean live biomass at Point Pelée was significantly greater than at Hillman in both woody and herbaceous categories in May and August. At Hillman herbaceous biomass decreased from 14.2 g dwt m^{-2} in the spring mean to 3.7 g dwt m^{-2} in the summer. A significant decline, from 1.2 g dwt m^{-2} in the spring to 0.6 g dwt m^{-2} g in the summer, was recorded for the woody biomass (Figure 6). At Point Pelée both herbaceous and woody biomass decreased from spring to summer, but not significantly (Figure 6).

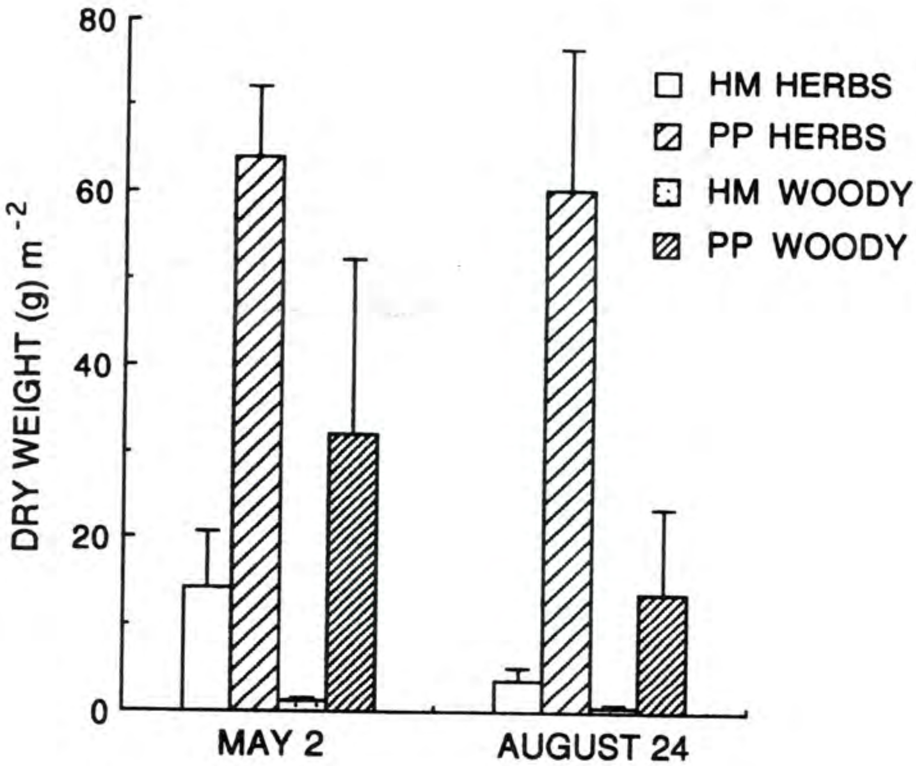

Figure 6. Live biomass (dwt gm^{-2}) of herbaceous and woody vegetation at Hillman Sand hills and Point Pelée (Mean ± Standard error; n = 10).

3.7 Effects of Variation in Grazing Pressure on *Trillium grandiflorum*

<u>3.7.1 Effects of grazing pressure of *T. grandiflorum* height</u>

Figure 7 shows that of *T. grandiflorum* plants from populations in sites exposed to higher grazing intensities were shorter than plants from sites exposed to moderate or low levels of grazing. *T. grandiflorum* plants in long term exclosures at Rondeau and at

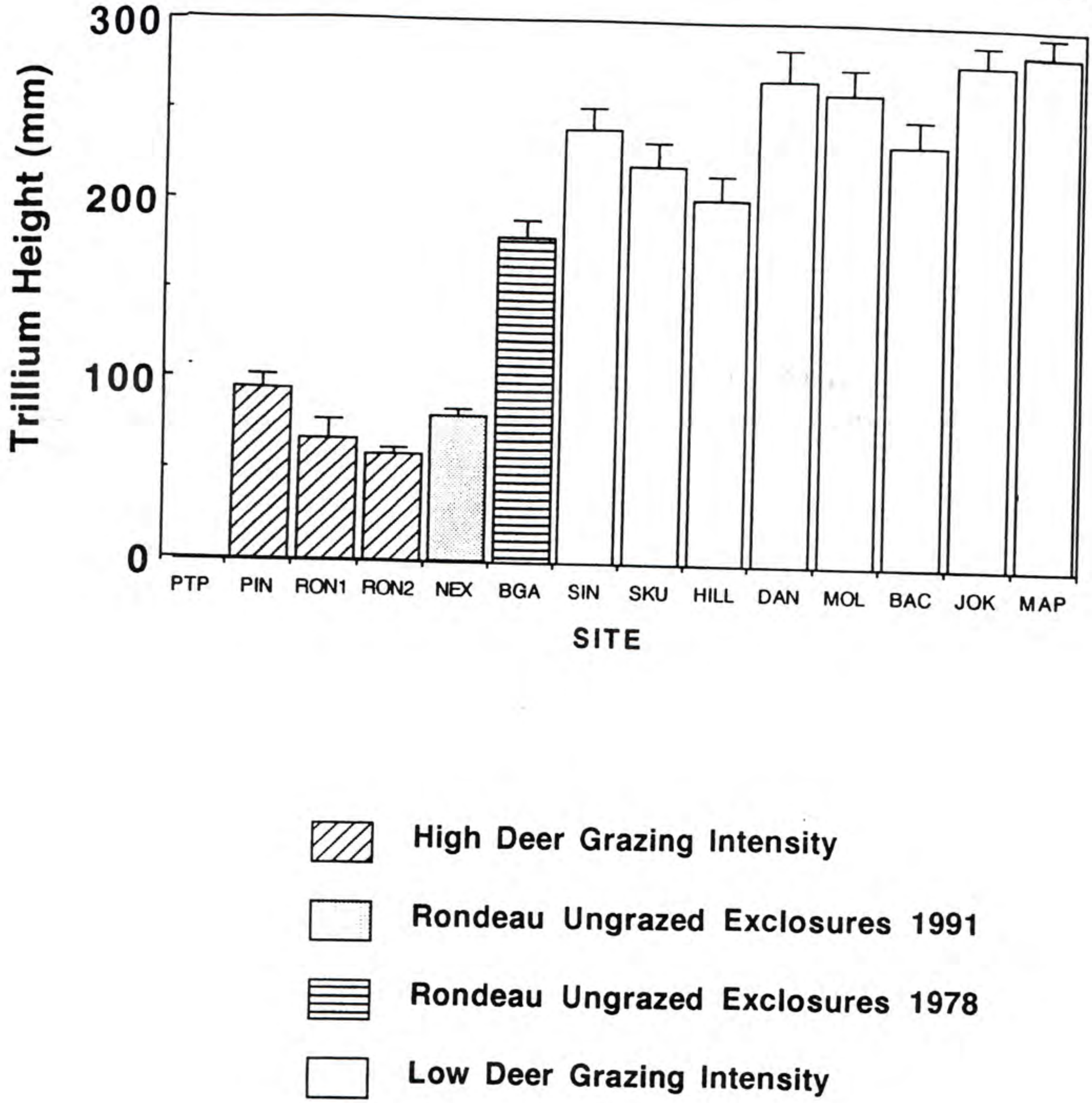

Figure 7. Maximum height of Trillium at various sites in southern Ontario. Point Pelée National Park had no Trillium. Five were found at Pinery. 35 or more individuals were sampled in each of the other sites (Mean height ± Standard error).

sites with low deer numbers were on average 200 mm to 300 mm in height while *T. grandiflorum* from areas exposed to grazing were under 100 mm in height (Figure 7). *T. grandiflorum* in exclosures erected in 1991 at Rondeau were significantly taller than control plants in adjacent deer grazed plots.

3.7.2 Effects of grazing pressure on *T. grandiflorum* flower production

At ungrazed or less intensively grazed sites, more than 45% of *T. grandiflorum* flowered while plants in heavily grazed sites did not flower at all (Figure 8). *T. grandiflorum* from heavily grazed sites that were protected from grazing by deer since 1991 did not produce any flowers in 1992.

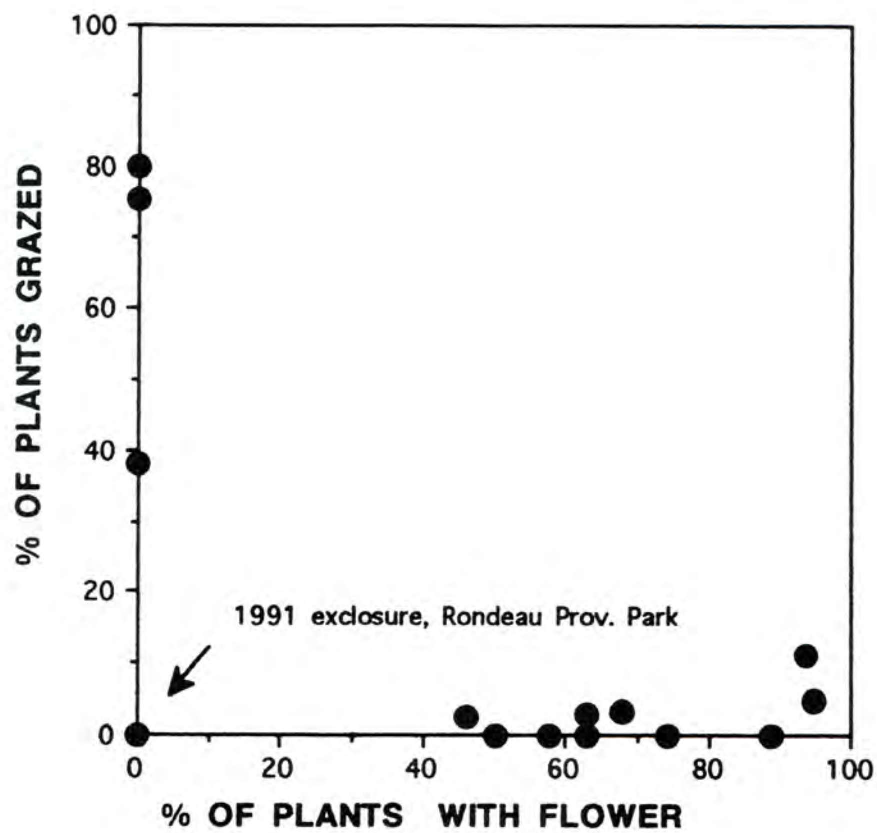

Figure 8. Percentage of marked *T. grandiflorum* grazed by deer versus percent of plants with flowers in 1992 at all sites.

4. Discussion

4.1 Plant Species Richness

Diversity can be defined as a measure of both the number and distribution of species present in a habitat (Magurran 1988). While the total number of plant species found in all study plots within each site (species richness) over the course of the growing season (Figure 3) was similar at Point Pelée and Hillman the distribution of these species was different (Figure 4). The higher densities (species m^{-2}) at Point Pelée compared to Hillman (Figure 4) indicate that species were more widely distributed at Point Pelée.

4.2 Plant Species Abundance

The two sites in this study were significantly different in terms of percent cover of component species. The common plant species differed between sites with respect to both mean maximum percent cover of species and numbers of individuals (Tables 1a, 1b and Figure 5). Spring ephemerals such as *T. grandiflorum, Arisaema triphyllum* and *Podophyllum pelatum* were found only at Hillman while weedy, invasive species such as *Galium triflorum, Solidago rugosa, Cerastium vulgatum* and "grazing" tolerant grasses, were more abundant at Point Pelée. A distinct "all or nothing" pattern exists for most members of the groups of species common to either Point Pelée or Hillman (Figure 5). It should be noted that individual plants of garlic mustard (*Allaria officinalis*), which were found in near equal frequencies at Point Pelée and Hillman (38 and 59), were five times greater in terms of maximum percent cover at Point Pelée (29% vs. 6%). This difference was due to the plants at Hillman being small and possibly seedlings. This may be a sign of the invasion of this species into the Hillman area. A similar pattern was observed at Rondeau

Provincial Park with respect to species abundance and grazing history. Five species that were more abundant in heavily grazed sites at Rondeau (Koh 1991b) were more abundant at Point Pelée (Table 1a). Six of the eight species (all spring flowering perennials) that were more abundant in the long term ungrazed exclosures at Rondeau (Koh 1991b) were found at Hillman (Table 1b). This indicates that heavily grazed sites at Point Pelée and Rondeau have similar plant communities.

4.3 Biomass and Plant Cover at Point Peleé and Hillman

The 1992 growing season was the second year that vegetation at Point Pelée was exposed to relatively low deer densities. The deer population density at Point Pelée was estimated at 36 deer km^{-2} for much of the 1980s. A cull in January 1991 reduced this number to approximately 7 km^{-2} (Landplan 1991). Studies in the early and late 1980s (Yaraskavitch 1983, Mosquin 1988) indicated that high deer numbers prevented woody species, e.g., Tulip tree (*Liriodendron tulipifera*) from being recruited into the canopy layer. Before the cull at Point Pelée, new woody growth on young trees was browsed as fast as it was produced (Mouland 1992 pers com.).

In 1992 live biomass and percent vegetation cover at Point Pelée was significantly greater than at another nearby Carolinian site, Hillman Sand Hills, which has always had a lower deer density (Figures 2 and 3). The effect of browsing on the amount of available new woody growth or herbaceous growth before the January 1991 cull was never rigorously quantified. Without pre-cull data it is difficult to determine whether or not the increases in biomass and vegetation cover are mostly a result of lower deer density or differences between the two sites in terms of abiotic factors such as temperature and canopy closure.

Other studies (Putman and Edwards 1989) including those in Carolinian sites (unpubl. data Koh 1992, and Landplan 1991) have indicated that a rapid increase in ground cover can occur following a decrease in deer grazing pressure. It seems likely that biomass and percent cover are limited by light availability at some plots in Hillman Sand Hills. Most of the herbaceous biomass and the percent cover were spring flowering species. At Point Pelée much of the percent vegetation cover was from weedy, invasive species, e.g., *Allaria officinalis* and *Cerastium vulgatum*. Another factor that may influence biomass production is nutrient availability.

4.4 Effect of grazing on *Trillium grandiflorum*

4.4.1 Effect of grazing on height of *T. grandiflorum*

T. grandiflorum is a long lived perennial found throughout southern Ontario (Kawano, Ohara and Utech 1986). During the growing season, *T. grandiflorum* plants store carbohydrates derived from photosynthesis in underground storage units called rhizomes. The next growing season the plant uses these reserves. It takes approximately seven years for *T. grandiflorum* to grow large enough to flower (Kawano, Ohara and Utech 1986). Browsed *T. grandiflorum* may be expected to accumulate less energy for the next season and to regrow as a smaller plant (Lubbers and Lechowicz 1989). This aspect of the life history of *T. grandiflorum*, coupled with it being grazed preferentially by deer (Crawley 1989, Anderson 1991), may be used to make inferences about the level of deer grazing pressure exerted on plant populations. There are clear differences among heights of *T. grandiflorum* from areas with different deer densities. *T. grandiflorum* plants at sites with high deer densities, such as Pinery Prov. Park (approx. 20 deer km^{-2}) and in unprotected plots at Rondeau Provincial Park (36 deer km^{-2}) (Landplan 1991) were in the 70-90 mm height range (Figure 7). These findings are similar to those recorded in sites with densities of 23-25 deer km^{-2} in Wisconsin (Anderson 1991). *T. grandiflorum* populations in areas of relatively low deer density (the average deer density for mature woodlots in southern Ontario is thought to be around 4 km^{-2} (Landplan 1991) had heights of 200-300 mm (Figure 7). These are similar to the 1991 heights of Trillium (190 mm) that had been protected from heavy grazing since 1987 in Wisconsin (Anderson 1991) and since 1978 at Rondeau (Koh 1991a).

It is also possible that relative changes in the height of individually marked plants could be used as an indicator of variation in deer population numbers. A significant increase in height was documented for *T. grandiflorum* exclosed for one year at Rondeau (90 mm) (Figure 7; column NEX) compared with *T. grandiflorum* in control (grazed) plots (70 mm) (Figure 7; column RON2). Thus, while we did not observe differences in grazed versus ungrazed plots within a season, presumably because the growth of all plants reflected the previous season's growing conditions, we did observe a response in Rondeau plants protected for one year. In a heavily grazed Wisconsin site, a population of *T. grandiflorum* that was exclosed in 1987 increased in height to 190 mm in 1991 when the last measurements were taken (Anderson 1991). The mean height of *T. grandiflorum* left in grazed sites remained between 106 and 111 mm.

4.4.2 *T. grandiflorum* flower production

Flowering rates of *T. grandiflorum* populations may also be used as indicators of browsing pressure. In areas of high deer density we found no flowers. At low deer densities where a maximum of 18% of marked *T. grandiflorum* were grazed, more than 40 % of *T. grandiflorum* produced flowers (Figure 8). While *T. grandiflorum* in heavily grazed sites in Rondeau showed a significant increase in height, they did not produce any flowers after one year of protection from grazing by deer (Figure 7 and Figure 8).

5. Conclusions

The increases in biomass and cover at Point Pelée may indicate that a recovery from overgrazing is occurring. However, a plant community presently dominated by many weedy or invasive species, e.g., *Galium triflorum, Solidago rugosa, Cerastium vulgatum* and *Allaria officinalis*, two years after the deer herd was reduced suggests that a longer period may be required before certain species such as spring ephemerals return.

It is possible that irreversible damage has occurred and many of the spring perennials including *Trillium* spp. have been extirpated from Point Pelée. The Canada yew, once abundant at Point Pelée, is thought to have been eliminated by deer (Landplan 1991). Crawley (1988) states that permanent community changes can occur due to selective herbivory.

Similarities in plant species composition between Point Pelée and grazed sites at Rondeau Provincial Park suggest that deer may have shifted or altered both plant communities in the same direction.

Trillium spp, as a preferred forage, is sensitive to grazing by deer and may be useful as an indicator species for monitoring grazing pressure. However, at this juncture in time, it is not present at Point Pelée although anecdotal evidence indicates it was present in the past. Ongoing seed bank studies will give information on the regeneration capacity of species such as *Trillium* spp. Seeding or reintroduction by artificial means may have to be considered for some species.

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