

Grazing Impacts of White-tailed Deer or “Culling Bambi to save the forest”

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Abstract

Large herbivores, such as white-tailed deer, can significantly determine the structure and composition of forest plant communities. In several National and Provincial Parks located on southwestern Ontario shorelines, deer overgrazing has been a major cause of habitat degradation. Few studies of herbivory have examined the link between herbivory-induced or mediated changes in environmental variables, and vegetation change. In this study we used ordination analyses (DCA, CCA,) to examine the effect of changes in understorey light levels on plant communities in Rondeau Provincial Park and other Carolinian forests.

In 1996, plant communities in forest stands with a past history of high deer densities (50 deer/km²) were compared with deer exclosures and other long-term ungrazed sites. Ordinations showed that older exclosures were similar to ungrazed sites and dominated by native plant species. Both differed significantly from grazed sites, which were dominated by non-native species. Newer exclosures and stands where deer densities were reduced differed from both grazed and long-term ungrazed sites, suggesting that these plant communities are following an intermediate or alternate recovery trajectory. Interestingly, despite the differences in plant community composition there were no significant differences in species diversity among treatments. Thus, measurements of diversity or species richness alone are inadequate descriptors of plant community change. From 1981-97 over 50% of trees were lost from permanent plots in Rondeau. The main reason is that deer overgrazing has prevented tree regeneration, causing increased understorey light levels. We suggest that in this more open forest, the normal recovery of native plant species is prevented, and the trajectory of some plant communities over time, may have been significantly altered. The major implication for park managers is that sustained deer herd reductions alone are not enough to ensure the recovery of vegetation—management for accelerated canopy closure may also be highly desirable.

Introduction

Grazing by large mammalian herbivores can have a major impact on the environment in which they live (Huntly 1991; Gill 1992). Effects include the alteration of the physical structure of their habitats (Huntly 1992), modification of nutrient cycling rates (Bazely and Jefferies 1985) and negative effects, at the individual plant level, on growth, reproduction and survivorship (Crawley 1986). The structure and composition of a plant community can be altered through selective feeding by herbivores and the variation of responses by plants to grazing (Huntly 1991; Rees and Brown 1992). Major perturbations such as overgrazing by herbivores can create instabilities in systems which lead to changes in the structure of the communities.

In some cases the changes are so severe the community no longer retains its original attributes (Bazely and Jefferies 1996).

Our previous research comparing the plant community composition at Rondeau and Pinery Provincial Parks and Point Pelee National Park, showed that these sites differed significantly from other forested sites with low levels of deer (Pearl et al. 1995). In this report, we present preliminary evidence from our current research which is aimed at investigating the hypothesis, that the plant community at Rondeau Provincial Park, which has been severely overgrazed by white-tailed deer since the mid-1970s, has undergone significant changes and has reached an alternative stable state. We use multivariate statistics to compare the change in plant community composition from 1992-1995 under two biomanipulations: a deer herd reduction (winter 1993) and in deer exclosures. Our prediction is that if an alternative stable state has been reached, then plant communities experiencing reduced deer grazing or protected from deer would not be observed to shift back towards the composition of plant communities found in long-term ungrazed exclosures in the park.

Methods

Plant Community Composition

In 1991 thirty sample stations were established along nine transects at Rondeau Provincial Park. A station included a grazed plot and a corresponding 2 x 2 m deer exclosure. Ten additional plots were established inside and outside of each of two large (0.4 ha) deer exclosures (Bennett and Gardiner locations) built in 1978 at Rondeau. In 1994 additional, new, 2m x 2m exclosures were built on grazed areas at a subset of the original 1991 stations.

The percent cover of individual plant species in 1m x 1m quadrats was scored in 1992 and 1995 in the following types of exclosure:

- a) 2m x 2m exclosures erected in 1991 (short-term recovery);
- b) 2m x 2m exclosures erected in 1994 at a subset of the original 1991 stations (short-term recovery);
- c) Bennett and Gardiner exclosures (long-term recovery); and,
- d) grazed areas adjacent to all exclosure stations and Gardiner and Bennett exclosures.

In 1992 these plots were sampled five times during the spring and summer, while in 1995, they were sampled twice: in the third week of May and the second week of July. For both years the maximum cover of all species recorded at each plot was determined and entered into a database.

Environmental Data: Soil Moisture and Canopy Cover

In 1996, near the centre of each sample station, a single hole was drilled to a depth of 1-1.75 m. An ABS pipe, with holes drilled at the bottom, covered with screening, was inserted into the ground. Water table levels were then measured weekly during the growing season, by lowering an electronic water detection device attached to the end of a tape measure into the well. Higher water tables were assumed to be indicative of a greater soil moisture regime. The percentage of tree foliage directly over a plot was estimated (in both 1992 and 1995) for use as an indicator of irradiance (light) levels.

Statistical Analyses

Ordination analysis is becoming increasingly popular in ecology. These multivariate methods are used as survey tools to characterize plant communities (Brown 1993, McIntyre and Lavorel 1994, Carleton and MacLellan 1994, ter Braak 1994, Fojt *et al.* 1995, O'Connor and Roux 1995) and as a method of analyzing the composition of plant communities as a result of experimental manipulation (Gibson and Brown 1992). We used Detrended Correspondence Analysis (DCA) and Canonical Correspondence Analysis (CCA).

Effects of Different Grazing Treatments

Data gathered in 1995 at all treatment types were used in both a DCA and a CCA. Exclosure type, a nominal environmental variable, was used in DCA (passively) and in CCA (constrained) along with soil moisture, canopy cover and exclosure age. This first set of analyses provides a current view of the sites in floristic terms, under different treatments (variations in grazing pressure and time) and the mutual position of sites in relation to measured environmental variables, passively and directly (DCA and CCA respectively). The resulting DCA ordination can be compared to the CCA to determine if any important environmental variables have been left out of the direct analysis. If the ordinations are similar then the measured environmental variables used in the CCA analysis will account for most of the theoretical variables extracted by DCA and thus the variation in species composition.

Time Series Ordinations of Plots under Different Grazing Treatments

Data from plots examined in 1992 and again in 1995 were used to generate a time series DCA ordination. A time series ordination shows the 'movement' of plots between two points in time. Plots that are more different between points in time 'move' relatively further than plots where floristic differences are less. This analysis will show if any changes occurred due to the biomanipulations: a) exclosing in 1991; and, b) reducing deer numbers in 1993.

Results

Effects of Different Grazing Treatments

The first DCA axis in the plot illustrating results for 1995 data, separated the Bennett and Gardiner exclosures (long-term exclosures) from the grazed plots and the short-term exclosures established in 1991 and 1994 (Figure 1). Some of these sites were separated by 3-4 S.D.(standard deviations) along the first axis, indicating great differences in species composition, with the sites most furthest apart having no species in common. This axis had an eigenvalue of 0.625 and accounted for 6.3% of the explained variation in the data. The first axis showed a species-environment correlation of 0.753 which indicate a good relationship between the measured environmental variables and the axis. The interset correlation coefficients with the measured environmental variables showed that canopy cover and the two long-term exclosure types (nominal variables) had the greatest influence on the first axis while the short-term exclosure types, the grazed treatment and exclosure age were negligible influences (Table 1). The species-environment-site triplot, with exclosure type shown as centroids, indicate a trend from spring perennials on the right to species commonly found in open habitats on the left (Figure 1). Separation of the grazed sites from short-term exclosures along the first axis was not obvious (Figure 1). The second DCA axis, with an eigenvalue of 0.49, accounted for 4.9%

of the species variation but was poorly related to the measured environmental variables with a species-environment correlation of only 0.546. When the analysis was repeated in a constrained CCA with the same environmental variables used passively in the DCA, eigenvalues only dropped slightly (0.53 compared to 0.62 for axis 1 and 0.49 compared to 0.37 for axis 2). This indicates the measured environmental variables used in the CCA accounted for the majority of the variation in the species data. Compared to the DCA, species-environment correlations for the first CCA axis increased from 0.75 to 0.94 and from 0.55 to 0.91 for the second axis. The intersite correlation coefficients for the first CCA axis were similar to the DCA and were mostly influenced by the two long-term enclosure types and canopy cover (Table 2 and Figure 2). The first CCA axis, which accounted for 5.3% of the varia-

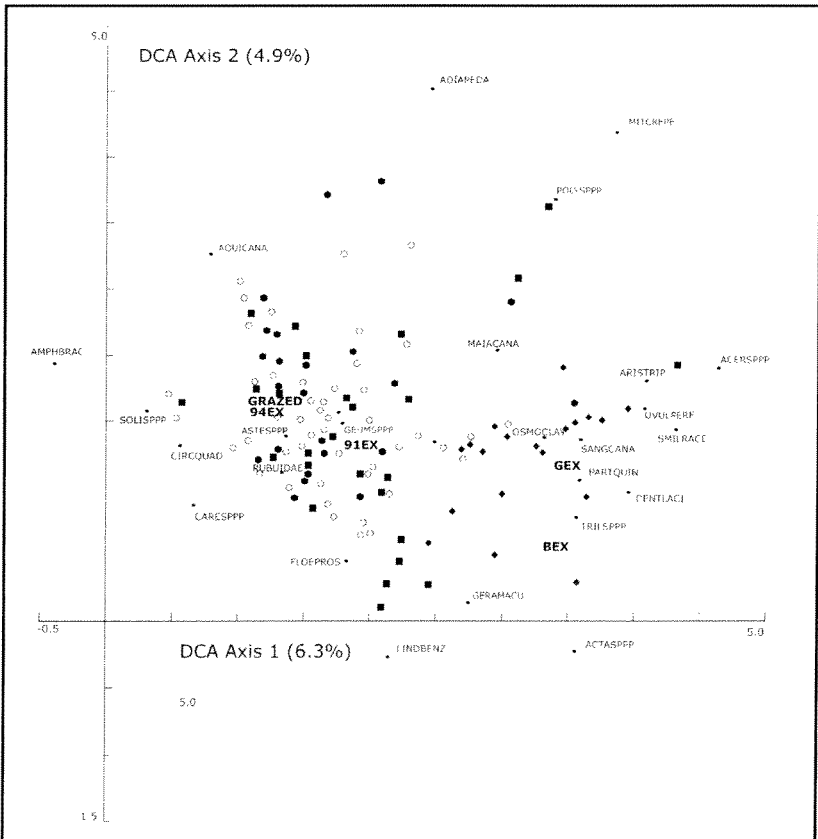


Figure 1: Species-environment-site triplot of DCA axes 1 and 2 on the 1995 Rondeau plant species data. The centroids of classes within the nominal environmental variable "Exclosure types" are shown in bold capital letters. All correlations are passive. Symbols show membership of a site to an enclosure type: ○ GRAZED = sites exposed to deer grazing, ■ 91EX = 2m x 2m exclosures established in 1991, ● 94EX = 2m x 2m exclosures established in 1994, ◆ BEX = sites within 0.2ha exclosures established in 1978, ◆ GEX = sites within 0.2ha exclosures established in 1978. Species codes are given in Appendix 1.

tion in the species data, separated Bennett and Gardiner exclosures from the grazed plots and the 1991 and 1994 exclosures (Figure 3). Separation of the grazed plots from the short-term exclosures along the first axis was not evident (Figure 3). The species-environment biplot of the CCA (Figure 2), where environmental variables are represented as arrows and exclosure types as centroids, also show a similar pattern to the DCA ordination (Figure 1) and indicate a trend from spring perennials on the right to species common in open habitats species on the left. The second CCA axis, which accounted for 3.7% of the species variation, was mostly influenced by one of the long-term exclosure types, Bennett Exclosure, and soil moisture (Table 2). Along the second axis, Gardiner sites and Bennett sites were separated from each other as well as the, 1991, 1994 exclosures and the grazed plots (Figure 3).

NAME	AX1	AX2
FR EXTRACTED	0.1171	0.0509
91EX	-0.1605	-0.0488
94EX	-0.2238	0.1592
GRZ	-0.3104	0.1203
GEX	0.4978	-0.0124
BEX	0.4795	-0.2960
SOIL MOIST	0.1758	0.2443
CANOPY	0.4541	-0.4382

Table 1: Inter set correlations of environmental variables with axes 1 and 2 of DCA on 1995 plant species data. All correlations are passive.

NAME	AX1	AX2
FR EXTRACTED	0.1843	0.1445
91EX	-0.2665	-0.1217
94EX	-0.2721	-0.0217
GRZ	-0.3238	-0.0037
GEX	0.7432	-0.5211
BEX	0.4708	0.7567
SOIL MOIST	0.2465	-0.5271
CANOPY	0.5620	0.1360

Table 2: Inter set correlations of environmental variables with axes 1 and 2 of CCA on 1995 plant species data.

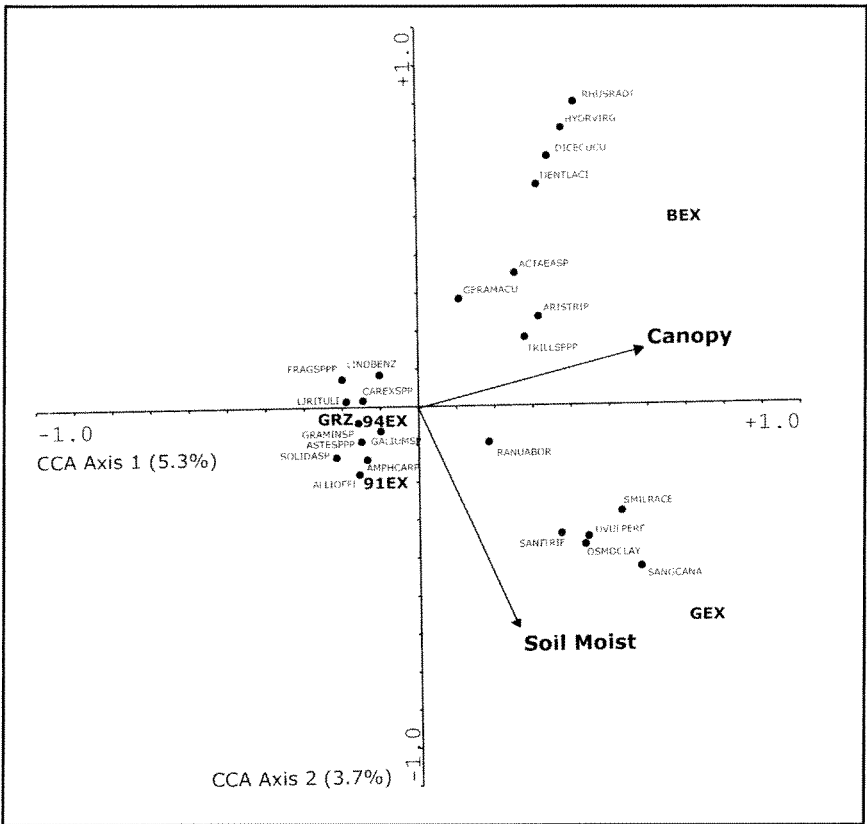


Figure 2: Species-environment biplot of CCA axes 1 and 2 on the 1995 Rondeau plant species data. Arrows indicate quantitative environmental data. The centroids of classes within the nominal environmental variable "Exclosure types" are shown in bold capital letters. Environmental codes are: GRZ = sites exposed to deer grazing, 91 EX = 2m x 2m exclosures established in 1991, 94EX 2m x 2m exclosures established in 1994, BEX sites within 0.2ha exclosures established in 1978, GEX = sites within 0.2ha exclosures established in 1978. Soil moist = Soil moisture regime as estimated by depth of water table. Canopy = Percentage of overhead area covered by foliage. Species codes are given in Appendix 1.

Time Series Ordinations

The first two DCA axes explain 6% and 5.1% of the variation in the species data. The sites were distributed in two groups with the long-term exclosures from both 1992 and 1995 in the lower right hand side of the ordinations and the short-term exclosures and the grazed plots from both years in the upper left (Figure 4). Since these sites were separated by 3-4 S.D. we can surmise that they were very different in terms of species composition and the sites most furthest apart would have no species in common. This separation distinguished plant species such as spring perennials found in forest understories (lower right) with species typical of open habitats (upper left) (Figure 4). Short-term exclosure groups did not appear to

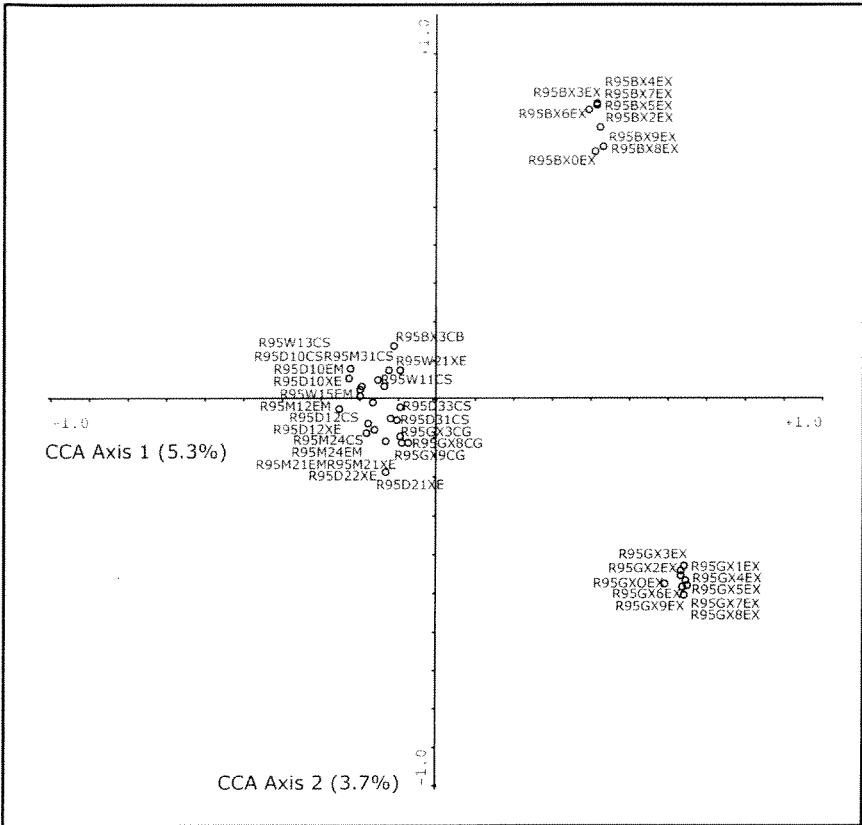


Figure 3: Site ordination on CCA axes 1 and 2 of the 1995 Rondeau plant species data. The last two digits of the site code indicate membership to a class within the nominal environmental variable "Exclosure Type". Class codes are: CS sites exposed to deer grazing, XE = 2m x 2m exclosures established in 1991, EM = 2m x 2m exclosures established in 1994, EX = sites within 0.2ha exclosures established in 1978.

have separated during the three years (from 1992 to 1995) of exclosing (Figure 4). These exclosures remained indistinguishable from grazed plots though free from deer for four years. Plots accessible to deer also did not appear to have changed between 1992 and 1995 (Figure 4) although deer numbers were massively reduced in 1993 from over 600 to 120. The long-term exclosures remained stable over the period of four years (Figure 4).

Discussion

Our view of plant community composition at Rondeau Provincial Park indicates that plant species have separated into two general groups. Native spring perennial species are primarily located in the two large exclosures established in 1978 when deer numbers were low (300) compared to numbers reached in the late 1980s (550), while species indicative of open habitats, that are either unpalatable to deer

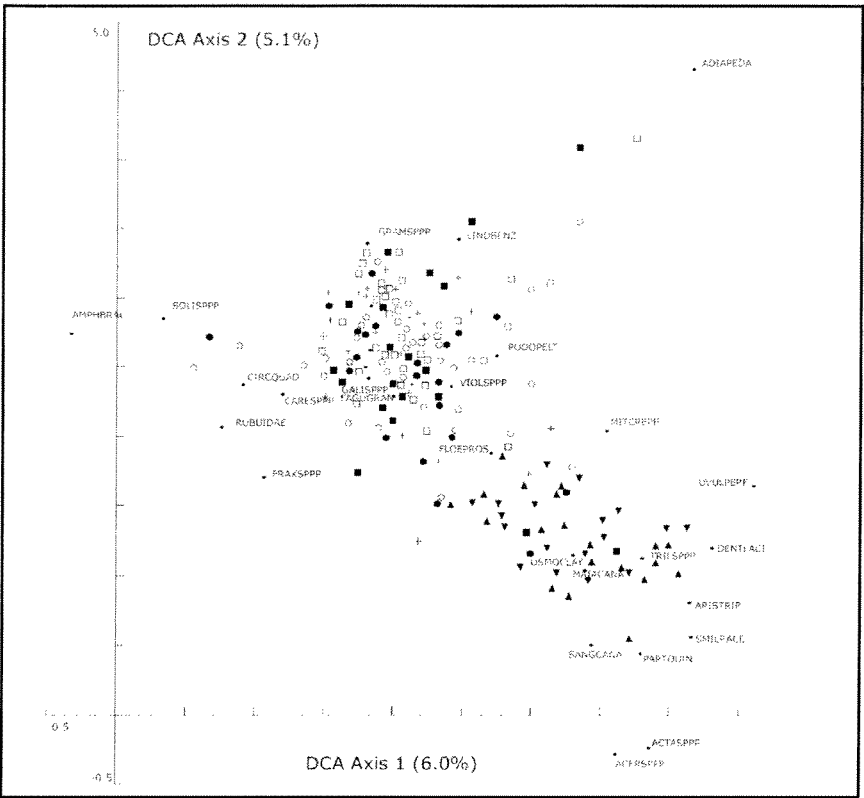


Figure 4: Species-site biplot of DCA axes 1 and 2 on the 1992-1995 Rondeau plant species data (time series). Symbols show membership of a point to year of data collection and enclosure type. Sites exposed to deer grazing: 1995 (O), 1992 (□); 2m x 2m enclosures established in 1991: 1995 (●), 1992 (+); 2m x 2m enclosures established in 1994: 1995 (■); sites within 0.2 ha enclosures established in 1978: 1995 (▲), 1992 (▼). Species codes are given in Appendix 1.

or are grazing tolerant, are dominant outside of these enclosures. These species include *Aster* spp., *Carex* spp., *Rubus* spp. and *Solidago* spp. Species such as *Trillium* spp., *Dentaria laciniata*, *Sanguinaria canadensis* and other spring perennials, after two decades of high deer numbers, are either absent or present in very low numbers outside of the long-term enclosures. Canopy cover was the single main influence on the floristic pattern at Rondeau.

Taken together with data on long-term change in forest composition (M. Timciska unpubl. data), which indicate that 50-80% of trees recorded in 1981 (Haggith 1982) were no longer present in 1996/97, and have not been replaced by natural regeneration, as a result of deer grazing, we suggest that light levels have increased to the point where the original, shade-tolerant native species are no longer able to re-establish, once they have been removed by deer grazing.

The time series DCA ordination showed that there was remarkably little change

between 1992 and 1995 in exclosures built in 1991, and following a deer reduction in the park in 1993. We suggest that increased light may also be responsible for the lack of recovery within these short-term exclosures. Increases in light may favour species that inhabit a more open forest environment at the expense of species found under closed forest understoreys. The species composition of plots exclosed in 1991 were similar to grazed plots even four years after being free of deer. This suggests that elimination of grazing may not be the only factor to be considered if the return to flora typical of southern Ontario forest understoreys is the desired goal at Rondeau. Current research is aimed at quantifying light levels more precisely.

Conclusions

At this stage, the single main conclusion that we can draw, is that in addition to reducing deer grazing pressure at Rondeau, additional management intervention, such as tree planting, to replace the missing cohorts of trees, and increase shade, may be required for the recovery of the understorey plant community.

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Appendix 1: Key to Plant Species Codes

ACERSPPP	<i>Acer sp.</i>
ACTASPPP	<i>Actaea sp.</i>
ADIAPEDA	<i>Adiantum pedatum</i>
ALLIOFFI	<i>Alliaria officinalis</i>
AMPHCARP	<i>Amphicarpa bracteata</i>
AQUICANA	<i>Aquilegia canadensis</i>
ARISTRIP	<i>Arisaema triphyllum</i>
ASTESPPP	<i>Aster sp.</i>
CAREXSPP	<i>Carex sp.</i>
CIRCQUAD	<i>Circaea quadrisulcata</i>
DENTLACI	<i>Dentaria laciniata</i>
DICECUCU	<i>Dicentra cucullaria</i>
FAGUGRAN	<i>Fagus grandifolia</i>
FLOEPROS	<i>Floerkea proserpinacoides</i>
FRAXSPPP	<i>Fraxinus sp.</i>
GALISPPP	<i>Galium sp.</i>
GERAMACU	<i>Geranium maculatum</i>
GEUMSPPP	<i>Geum sp.</i>
GRAMSPPP	<i>Graminoids</i>
HYDRVIRG	<i>Hydrophyllum virginianum</i>
LINDBENZ	<i>Lindera benzoin</i>
LIRITULI	<i>Liriodendron tulipifera</i>
MAIACANA	<i>Maianthemum canadense</i>
MITCREPE	<i>Mitchella repens</i>
OSMOCLAY	<i>Osmorhiza claytoni</i>
PARTQUIN	<i>Parthenocissus quinquefolia</i>
PODOPELT	<i>Podophyllum peltatum</i>
POLYSPPP	<i>Polygonatum sp.</i>
RANUABOR	<i>Ranunculus abortivus</i>
RHUSRADI	<i>Rhus radicans</i>
RUBUIDAE	<i>Rubus idaeus</i>
SANGCANA	<i>Sanguinaria canadensis</i>
SANITRIF	<i>Sanicula trifoliata</i>
SMILRACE	<i>Smilacina racemosa</i>
SOLISPPP	<i>Solidago sp.</i>
TRILSPPP	<i>Trillium sp.</i>
UVULPERF	<i>Uvularia perfoliata</i>
VIOLSPPP	<i>Viola sp.</i>