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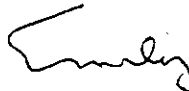
Dear Brian:

Here is my report on resampling of the deer exclosures at Morristown NHP. The data are entered in a Lotus 123 spreadsheet and are printed out from that. I will be glad to send a copy of the disk to the park if it would be useful. I will include the originals of the data sheets with the copy of the report for the park. As you can see, I can detect no effect of the exclosures, but with only three or four years of data and such a limited sample this is not surprising. (Adding the 1987 data to my analyses does not change this conclusion.)

I hope to get to work soon on a proposal for continued work at Morristown, in consultation with park personnel, especially Bob Masson. Right now I am trying to get the Saratoga project under control and getting started with the semester and a course for which there is no textbook, on the history of human impact on the landscape.

I hope that things are going well for you, and I look forward to continuing this kind of work.

Sincerely,



Emily W. B. Russell
Research Associate Professor

cc: Lynn Wightman
Robert Masson

DEER EXCLOSURE SAMPLING DATA, 1988-1991
MORRISTOWN NATIONAL HISTORIC PARK

Emily W. B. Russell
September, 1991

Introduction

Concern about the impact of large deer populations on the vegetation at Morristown National Historic Park prompted the establishment of 5 deer exclosures in 1987-1988. A gross estimate of the impact of herbivory can be made by observing if the vegetation in these exclosures changes over time differently from that in similar areas that are accessible to the deer. This system of exclosures therefore tests the null hypothesis that excluding deer will have no effect on the vegetation within the exclosures.

The five 20' x 20' exclosures are located in each of five different vegetation types of the park, with a control plot located adjacent to each exclosure. Details of the exclosures are given in the "Deer Exclosure Manual" (Anonymous nd). The surrounding fences are 12' high, and include two 8" x 8" holes to allow smaller herbivores to enter the exclosure. Vegetation (from Ehrenfeld 1977) for the 5 exclosures is as follows

#1 - mature broadleaf forest of mixed oak (Quercus spp. and yellow poplar (Liriodendron tulipifera)

#2 - successional forest of white ash (Fraxinus americana) and yellow poplar

#3 - open field (mowed occasionally)

#4 - successional forest of white ash and black locust (Robinia pseudoacacia)

#5 - mature forest of mixed oak

Sampling Dates

The first and second exclosures were set up and sampled in late October 1987. Exclosures 3-5 were set up in June 1988, and all exclosures and control plots were sampled at that time. Further sampling of all exclosures and controls took place in August 1989, September 1990 and July 15-16, 1991. It is immediately obvious that sampling dates have varied through most of the growing season, though most were in late summer or early fall so that spring flora was not included. Most species listed (Table 1) remain visible for most of the summer, so unless they were destroyed by herbivory, should be present throughout the sampling time. The density of cover, however, varies throughout this time period, so that rare species are more apt to be missed later in the season than earlier. One species, water pennywort, is present in early spring and dies back completely by mid-summer, so it was observed only in the 1988 sampling.

Sampling methods

For the first four years the percent cover of all species in one 1 m² plot, chosen haphazardly (?), was sampled for each exclosure and control site. In 1991 a more intensive and randomized sampling procedure was initiated. A 5 x 5 m plot was marked off in the middle of each exclosure and control, to avoid problems with edge effect in the exclosures. Within the 5 x 5 m plot, 3 points, located by pairs

of random numbers, each marked the corner of a 1 m² subplot. Data were recorded using cover classes as follows:

- r = solitary with small cover
- + = few with small cover, or solitary with <5% cover
- 1 = numerous with < 5% cover
- 2 = 5 - 25% cover
- 3 = 26 - 50% cover
- 4 = 51 - 75% cover
- 5 = 76 - 95% cover
- 6 = 96 - 100% cover.

Results

Eleven of the 51 species identified in 1991 were found only in the exclosures (Table 2). Of these, however, 5 were found also in non-enclosed plots sampled to study the recovery from fire (plots # 6s and 6n), and were generally observed outside exclosures. Six were found only in cover categories + or r and generally in only one subplot. Only one, multiflora rose, was found with cover greater than 5% in 3 of the five exclosures and in none of the unenclosed plots.

To test differences in overall effects, several synthetic indices were computed to compare the exclosures with control plots over time. These indices used presence/absence data for the species, because of the differences in sampling dates and thus cover for different years. The total number of species found a plot is a simple measure of diversity. The numbers remained fairly stable from 1988 to 1989, then generally decreased in 1990 and increased in 1991. The nadir in 1990 may have been caused by the date of sampling, when the dying charcoal-

hearth grass produced a thick litter that obscured other species that might be present. The increase in 1991 was probably due to sampling three rather than one subplot, and possibly more thorough searching for small specimens of the rarer species.

Indices that compare exclosures with paired controls should give a more consistent indication of change over time. The two indices used were Sorenson's Percent similarity index (Mueller-Dombois and Ellenberg 1974) and the ratio between the number of species in the exclosure and that in the control. Sorenson's index, $S = 2C/(A + B)$, where C = number of species in common, A = number of species in plot A (exclosure), and B = number of species in plot B (paired control). Neither of these indices indicated any clear trend over time (Figure 2).

While there were more species in the exclosures than in the controls, this relationship was true as soon as the exclosures were set up, so is apparently not the result of excluding deer.

Discussion

The exclosures do not show any apparent effect of excluding deer for 3-4 years. There are several possible reasons for this. First, deer may not be having any effect. However, given their prevalence and herbivory, it does not seem likely that they are having no impact on the vegetation. Second, the effect may not have shown up in this short time. Whatever effect there may be would already have altered the vegetation before the exclosures were set up. It would then take more than 3-4 years for recovery, especially if this required seed recruitment. Species that had become well established under grazing might not easily be diminished by removal of grazing pressure. Third,

the sample size is very small. Both the small size and the small number of exclosures makes it difficult to separate the effects of exclosure location from effects of grazing. Changing dates of sampling and quality of identification of species are additional confounding factors.

Recommendations

1. More plots are needed for valid comparisons of treatment effect. I would recommend at least three in each vegetation type. These might be coordinated with a permanent vegetation sampling plot program.

2. Future sampling should include 3 randomly located subplots/exclosure and /control. This did not take a great deal of time, but provides data that can be analyzed statistically.

3. The controls should be fenced in a way not to exclude deer but to provide perches for birds comparable to those around the exclosures and to discourage trampling.

4. A competent botanist should do the sampling. There are several identifications in previous years that are questionable, for example confusing Oxalis and "clover." It is likely that Oxalis has been present from the beginning, but was confused with clover. Several identifications in the genus Eupatorium are also questionable.

The consistency of the data within each exclosure, among the three subplots, was encouraging (see Table 2). The vegetation in the exclosures and controls is apparently fairly homogeneous, and this may also be the case within each stand, making comparisons among different effects in the different stands possible.

References Cited

Anonymous. n.d. Deer Exclosure Manual. Morristown National Historical Park

Ehrenfeld, J. 1977. Vegetation of the Morristown National Historic Park: Ecological analysis and management implications. Report, National Park Service Cooperative Research Unit, Center for Coastal and Environmental Studies, Rutgers University, New Brunswick, NJ

Mueller-Dombois, D. and H. Ellenberg. 1974. Aims and Methods of Vegetation Ecology. John Wiley and Sons, New York

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3c.2 3c.3

Exlosure #/sublot #	1,1	1,2	1,3	1c,1	Sept 5, 1995												3c,2	3c,3
Species																		
Acer rubrum				r														
Agrostis sp/																		
✓ Alliaria officinalis	1																	
✓ Apocynum cannabinum																		
✓ Arisaema triphyllum		r	r															
Berberis thunbergii																		
Carex sp.1		+																
Carex sp. 2 (wider leaves)																		
Celastrus orbiculatus	2																	
Circaea quadrisulcata																		
Cirsium sp.																+		
Cynanchum nigrum?																r		
Euphorbia esula																4		
✓ Eupatorium rugosum	4	2	5	2												1		
Galium asprellum																1		
✓ Galium sp.																2		
✓ Geum canadense																r		
Hemamelis virginiana																r		
Lindera benzoin	2	1																
Linaria vulgaris													+	r		+		
Liriodendron tulipifera	r	2	r	+	r													
Lonicera japonica		+	r			3	3	5	r	r	1							
Maianthemum canadense			r															
Microstegium vimineum						5	5		6	5	5	1	1		2	+		
✓ Mitchella repens																+		
Oxalis stricta												r	+		r	+		
Panicum sp. (broad-leaved)												2	2	+	r	1		
Parthenocissus quinquefolia			r									1	+	3		+		
Phytolacca americana				r	r													
Pilea pumila																		
✓ Polygonum persicaria																		
Polygonum scandens													+	1				
Prunus serotina																		
Rosa multiflora						+	2	5							5			
Rubus phoenicolasius							2	2										
Rubus sp.												1	1	1		r		
Solidago sp. (lanceolate)			2										+		1	r		
Solanum carolinense												+	+	1		r		
Toxicodendron radicans	1	r										1		+	2	+		
Uvularia perfoliata	+	r																
Vaccinium angustifolium																		
Viburnum acerifolium																		
Vicia sp.												r						
Viola sp.														r		+		
unknown 1 (Brassicaceae)												r						
unknown grasses													+		1	5		
unknown 2. composite tall													1	+		5		
unknown 3. thistle															r	4		
unknown 4. maybe Ranunculus															r			
unknown 5															r			
unknown 6 - basal. halberd leaves																		
leaf litter																		
deer bedding																		
compressed vegetation												1						
Total # species	9	9	6	4	7	5	4	4	6	2	5	3	14	13	10	7		
Ave. for plot		8			5.3			4.7			3.3		12.3		10.3	12		

Jockey Hollow Exclosure and Control Data, July 15, 16, 1991, cover classes

Exclosure #/sublot #	4,1	4,2	4,3	4c,1	4c,2	4c,3	5,1	5,2	5,3	5c,1	5c,2	5c,3	6n,1	6n,2	6n,3	6s,1	6s,2	6s,3
Species																		
Acer rubrum								r					+					
Agrostis sp.																		
Alliaria officinalis	1	1	2			r							r	+	+			
Apocynum cannabinum																		
Arisaema triphyllum	2	2	2										+			2	r	
Berberis thunbergii																		
Carex sp.1							2			2	1		+					
Carex sp. 2 (wider leaves)													r			+	2	
Celastrus orbiculatus																		
Circaea quadrisulcata	2												r	1				
Cirsium sp.																		
Cynanchum nigrum?																		
Euphorbia esula																		
Eupatorium rugosum	+				r									2	2	r	+	+
Galium asprellum																		
Galium sp.																		
Geum canadensis																		
Hemamelis virginiana							+		+									
Lindera benzoin			r													1		
Linaria vulgaris																		
Liriodendron tulipifera														r	r			r
Lonicera japonica		r	2															
Maianthemum canadense																		r
Microstegium vimineum	6	6	6	6	4	5							r	2	+			
Mitchella repens							+		+	1	+	+						
Oxalis stricta	r	r	r															
Panicum sp. (broad-leaved)																		
Parthenocissus quinquefolia		r	r										r					
Phytolacca americana																		
Pilea pumila																r		
Polygonum persicaria			r											+	+			
Polygonum scandens																		
Prunus serotina																r		
Rosa multiflora	+	2																
Rubus phoenicolasius																		
Rubus sp.			+													+	+	
Solidago sp. (lanceolate)																		
Solanum carolinense																		
Toxicodendron radicans		r		r														
Uvularia perfoliata																r		r
Vaccinium angustifolium							r	+	+				+			r		
Viburnum acerifolium															r			
Vicia sp.																		
Viola sp.	+	r																
unknown 1 (Brassicaceae)																		
unknown grasses																		
unknown 2, composite tall																		
unknown 3, thistle																		
unknown 4, maybe Ranunculus																		
unknown 5																		
unknown 6 - basal, halberd leaves																1		
leaf litter							6	6	6	6	6		6	6	6	6	6	6
deer bedding					2													
compressed vegetation						2												
Total # species	8	9	9	3	3	3	4	2	3	2	2	1	5	9	10	6	4	5

Legends for exclosure plots

1. Coefficient of community. Number of species common to both plots = C, number of species in exclosure = A, number of species in paired control = B. Community coefficient = $2C/A+B$. Mean and one standard deviation from the mean plotted for each year, based on 5 exclosures. Values for each exclosure shows as a point.
2. Ratio of species. Total number of species in exclosure divided by total number of species in paired control. Plotted as in 1.
3. Total species with cover $\geq 5\%$. This includes all species with 5% or greater cover in any subplot in each exclosure and each control for each year.
4. Native species This is the same as 3, but for species native to northern New Jersey.
- 5-8. Percent of species that are native for each exclosure and control. All species in plot 5 were native.

Tentative conclusion: I see no significant trends except in 3 and 4, where exclosures seem to have gained in total number of species as well as number of native species with cover $\geq 5\%$. The change came about fairly early, i.e., from 1989 to 1992 when the exclosures gained in both categories.

