Proceedings of the Indiana Academy of Science
(1995) Volume 104 p. 35-41

IMPACT OF WHITE-TAILED DEER ON PLANT COVER AND BIOMASS IN POTATO CREEK STATE PARK, ST. JOSEPH COUNTY, INDIANA

Victor Riemenschneider
Department of Biological Sciences
Indiana University South Bend
South Bend, Indiana 46637-7111

Timothy B. Cordell
Potato Creek State Park
North Liberty, Indiana 46554

and

Bob Allison
313 Parkovash
South Bend, Indiana 46617

ABSTRACT: Potato Creek State Park is one of Indiana's most visited state parks, and white-tailed deer observation is one of its attractions. The protected deer herd has increased dramatically and is having an adverse effect on some plant communities within the Park. In May and June 1993, herbaceous biomass was sampled in two of the three deer exclosure plots (paired fenced and unfenced) in the Park. In the forested habitat, *Claytonia virginica* and *Acer saccharum* showed the greatest negative impact by browsing. The mean dry weight biomass inside the exclosure was 2.67 times greater than outside the exclosure ($p < 0.01$). A percent cover study using similar procedures in the spring of 1994 supported the same conclusions. The meadow site (Summer's Pond), which is dominated by grasses and goldenrod, did not show significant biomass differences between the fenced and unfenced plots.

KEYWORDS: Biomass, deer foraging, forests, *Odocoileus virginianus,* park management, plant cover, white-tailed deer.

INTRODUCTION

Potato Creek State Park is located in southern St. Joseph County, four miles east of North Liberty, Indiana. The park covers six square miles (1,555 ha), and its topography "is characterized by low ridges and swales with undulating to rolling relief, although rugged hills do occur" (Indiana Division of State Parks, 1976). Prior to the park's development in the mid-1970s, the land was used primarily for agriculture and livestock grazing, although several wood lots existed. Development of the park's facilities and natural succession have changed the park's landscape to a mixture of mowed areas, old fields, wetlands, thickets, and forests — prime habitat for white-tailed deer (*Odocoileus virginianus*).

Indiana state parks serve a variety of recreational needs and "preserve outstanding examples of Indiana's natural, historic, and scenic heritage" (Indiana Division of State Parks, 1983). Potato Creek State Park is one of the most visited

Indiana State Parks. Wildlife viewing, particularly white-tailed deer observation, draws many visitors to Potato Creek State Park. With the absence of the white-tailed deer's natural predators, the gray and red wolf (*Canis lupus* and *C. rufus*) as well as the mountain lion (*Felis concolor*), and the prohibition of hunting in Potato Creek State Park, the deer population has increased virtually unchecked.

Increasingly, ecologists, foresters, and botanists are detailing the need to protect economically valuable and sensitive plant communities from browsing by high densities of white-tailed deer (Girard, *et al.,* 1993; Jones, *et al.,* 1993; Miller, *et al.,* 1992; Strole and Anderson, 1992). In addition, Porter (1991) noted that "Browsers and grazers are selective in their diet. The degree of selectivity varies, but the point is that not all that is green is equally preferred." As a result, high deer densities are changing the composition of plant communities.

In 1990, park personnel established deer exclusion plots (paired fenced and unfenced) in three different habitats within the park: a forested area (Swamp Rose) in the northeast section of the park, a meadow area (Summer's Pond) near State Route 4, and a secondary succession site (Pear Road) in the northwestern sector. The Swamp Rose site is located in a second growth beech-maple forest adjacent to the Swamp Rose Nature Preserve. The canopy is dominated by sugar maple (*Acer saccharum*) with spicebush (*Lindera benzoin*) as the dominant shrub. Canopy trees range to 36 cm dbh, and the herbaceous layer has a typical vernal flora. The Summer's Pond site is dominated by meadow fescue (*Festuca elatior*) and tall goldenrod (*Solidago altissima*). A few multiflora rose (*Rosa multiflora*) and two trees, the largest a 7 cm dbh box elder (*Acer negundo*), are in or adjacent to the site. Tree seedlings were planted in the area of Summer's Pond in 1989 (D. Clute, pers. comm.). The Pear Road site consists of a dense sugar maple (*Acer saccharum*) sapling thicket, covering about 50% of the plot with stems measuring from 1.0 to 7.0 cm dbh. A great variety of alien and native old field species cover the remainder. This last site was not included in our study due to the considerable diversity within and between fenced and unfenced plots.

In 1991, park personnel begin a monitoring program, consisting of herbaceous cover studies (three, permanently marked, 0.9 m^2, subplots in each plot) and photographic documentation, to record seasonal and yearly changes at these three sites (Cordell, 1992). When data from cover studies for the first three years were examined, they failed to show any statistically significant differences between subplots inside and outside the deer exclosure, although differences were obvious to the casual observer at the Swamp Rose site (Cordell, 1992). Two conclusions were obvious from these observations and the data: 1) the data were highly variable, and 2) the present design was not fulfilling the initial monitoring objective of recording change. Consequently, the present study was designed to provide a revised monitoring method. A biomass study was conducted in 1993 and a revised cover study in spring of 1994.

The Swamp Rose and Summer's Pond sites were chosen for the 1993 biomass sampling because 1) the exclosure plots were already established, 2) one site had visually observable differences and the other did not, 3) their fenced and unfenced plots had a similar flora, and 4) they were contrasting habitats. Since biomass sampling is destructive and cannot be used annually, the authors decided to try a revised cover study at the Swamp Rose site in 1994. The Swamp Rose site was

selected for the expanded percent cover study, since it showed statistical differences in the biomass sampling of 1993. The authors hoped to determine if the revised cover study would detect the differences seen in the 1993 study.

MATERIALS AND METHODS

Three deer exclusion sites were established at Potato Creek State Park in 1990 by erecting a 2.4 m high woven wire fence around one plot approximately 12 m square at each site. The fences effectively prevented deer and other large grazers from browsing the vegetation within the enclosure but did not prevent the entry of smaller grazers, such as eastern cottontail (*Sylvilagus floridanus*) and woodchuck (*Marmota monax*). A second, unfenced, plot the same size as the fenced plot was located about 2 m to the west or east of each exclusion plot and was open to browsing by all animals.

The fenced plots were not perfectly square, so a smaller (10 m x 10 m) study plot was marked off within both the fenced and unfenced areas. For the biomass study in 1993, the study plots were subdivided into columns (15 cm wide) and rows (30 cm wide). Ten sample rectangles within each study area were randomly selected. Three permanent cover study subplots and a 30 cm buffer zone were excluded from the biomass study to preserve these plots for continuing the studies began in 1991. Sample plot number sequence was determined by a random drawing, but sampling took place from east to west to reduce trampling impact on the sample area.

The study plots were clipped at ground level, after a 15 cm by 30 cm aluminum frame was placed over the sample plot. Woody plants one year or older were not harvested. The plant samples were immediately placed into plastic bags and sealed for return to the laboratory. Total fresh weight and species fresh weight per sample were determined in the laboratory using an electronic balance (0.01 g accuracy). Since the drying oven was too small to keep material separated by species, the plant material from a single study plot was recombined for oven drying. The plant samples were cut into smaller pieces (3 cm), placed in screen drying trays, and placed in the oven for 48 hours at 100 ^{o}C. After cooling for 10 minutes in desiccators, the dried samples were weighed.

In the spring of 1994, percent cover values were determined for ten random study plots at the Swamp Rose site using the 10 m x 10 m plots and sample locating procedures of the biomass study of the previous spring but with larger row (50 cm) and column (20 cm) widths. An aluminum sampling frame (20 cm x 50 cm) was placed over each study plot, and the percent cover was estimated for each species rooted within the frame. The edges of frame were marked at 10 cm intervals to aid in cover estimation (each 10 cm block defined 10 percent of frame area).

Statistical analyses were performed with *SigmaStat 1.01* and *Quattro Pro 5.0.* Data from fenced and unfenced sites were compared using a two-sample *t*-test or a Mann-Whitney test, if normality or equal variance tests failed. Probability values (p) quoted in the text are the probability that the null hypothesis was true.

Table 1. Herbaceous biomass in Potato Creek State Park deer exclosure study sites in meadow and forest habitats.

	Biomass Dry Weight (g/m^2)			
	Inside Fenced Area		Outside Fenced Area	
Plot Number	Summer's Pond	Swamp Rose	Summer's Pond	Swamp Rose
1	281.2	12.56	656.9	0.31
2	324.6	20.33	1164.7	8.00
3	337.5	25.78	437.6	9.22
4	639.4	6.67	383.8	0.09
5	288.5	13.56	288.5	5.78
6	409.6	21.33	230.1	24.22
7	573.8	19.33	332.9	10.33
8	615.5	28.44	275.0	0.36
9	379.8	18.44	685.6	7.33
10	188.2	34.00	264.7	9.33
Average	403.8	20.04	472.0	7.50
Standard Deviation	154.7	8.03	291.0	7.11

RESULTS AND DISCUSSION

Biomass data collected at Summer's Pond on 1 June 1993 and at Swamp Rose on 12 May 1993 are presented in Table 1. The data from the Swamp Rose exclosure site clearly reveal that deer are having an impact on the herbaceous communities. The mean biomass of all samples from inside the exclosure is 2.67 times greater than from outside the exclosure and is highly significant ($p = 0.002$). The means at Summer's Pond are not significantly different ($p = 0.521$), but the biomass was greater outside than inside the exclosure. The biomass data appear to be a more sensitive indicator of grazing impact than the results of the previous studies, which used three subplots and percent cover data (Cordell, 1992). The revised cover study at the Swamp Rose site in 1994 did show significant differences (Table 2) using the same number of plots as the biomass study. However, various combinations of the three sample plots from the cover study did not show significant differences.

Fresh weight biomass and cover values for the ten most prevalent species growing inside and outside the exclosure at Swamp Rose are presented in Table 3. Maple (*Acer* sp.) had 3.86 times more biomass inside the exclosure. Strole and Anderson (1992) noted that *Acer,* although not a preferred browse species, made up a relatively large proportion of the browse diet because of its high abundance. The deer at Potato Creek State Park may be using less preferred species due to the high deer density. Porter (1991) noted that deer populations will have the greatest effect on vegetation, when their populations are above the carrying capacity of the habitat.

The deer population has increased considerably over the last decade in Potato Creek State Park, from 77 total deer in the park (5 per sq km) in 1981 (R. Grimes, pers. comm.) to counts of 95.7, 79.5, 96.9, and 83.6 per sq. km (248, 206, 251, and 214 per square mile) in 1991, '92, '93, and '94, respectively. The recent counts were made using volunteers and park staff to observe three sides of a square

Table 2. Percent cover data for ten samples from fenced and unfenced plots at the Swamp Rose site in Potato Creek State Park, St. Joseph County, Indiana.

Plot Number	Percent Cover Fenced Plot	Percent Cover Unfenced Plot
1	36	23
2	124	9
3	73	22
4	83	14
5	99	4
6	97	70
7	87	50
8	112	42
9	74	7
10	80	34
Median	85	22.5
Mean	86.5	27.5
Standard Error	7.6	6.8

mile of park land while a line of people walking from the fourth side flushed the deer (Jones, 1993; unpub. park records). Jones, *et al.* (1993) note that deer densities in excess of 7.7 per sq km (20 per square mile) appear to decrease species richness, species abundance, and species composition. The Potato Creek deer herd is more than ten times greater than this limit.

Spring beauty (*Claytonia virginica*) had the greatest biomass and percent cover differences between the fenced and unfenced plots (Table 3) but failed the Mann-Whitney test for significance at the 10% level. Cordell (1992) noted that spring beauty stops at the fence line of the exclosure, suggesting that deer are successfully utilizing and removing spring beauty from outside the exclosure area. Spring beauty is one of the first species to provide new green foliage in the

Table 3. Biomass and percent cover for ten common species in the Swamp Rose deer exclusion site in Potato Creek State Park.

	Biomass (fresh weight), 1993				Percent Cover, 1994			
	Inside Fence		Outside Fence		Inside Fence		Outside Fence	
Species	Freq. (%)	Ave.Wt. (g/m^2)	Freq. (%)	Ave.Wt. (g/m^2)	Freq. (%)	Ave. Cover (%)	Freq. (%)	Ave. Cover (%)
Acer Saccharum	80	27.4	20	7.1	40	2.3	30	0.9
Claytonia virginica	80	60.8	10	1.2	100	13.0	50	0.9
Dentaria laciniata	40	3.1	10	3.1	40	3.7	50	1.9
Dicentra canadensis					100	15.9	70	5.5
Dicentra cucullaria					60	12.6	50	6.0
Dicentra sp.	90	26.7	60	13.2				
Erigenia bulbosa	40	13.6	40	13.0	70	7.8	50	2.6
Erythronium americanum	30	5.9	20	1.6	50	5.4	50	1.1
Viola canadensis					0	0	20	2.0
Viola pensylvanica					60	6.9	0	0
Viola sororia					30	1.9	0	0
Viola sp.	60	32.4	50	13.00	20	0.2	50	2.3

spring. If the deer herd is above its carrying capacity and is starving from an insufficient winter diet of woody twigs, the herd would find the early foliage and flowers of spring beauty very appealing. Continued grazing at present levels could eliminate spring beauty from the herbaceous layer. Kelly and Anderson (1993) found a significant reduction in both biomass and reproductive units of spring beauty in an Illinois forest. However, spring beauty is not the only plant to grow in the spring, and the impact on other species is variable. Percent cover values for *Dicentra* sp. and pepper-and-salt (*Erigenia bulbosa*) showed large differences between the fenced and unfenced sites (Table 3) but were not significantly different (10% level, Mann-Whitney). In addition, cutleaf toothwort (*Dentaria laciniata*) showed no difference in biomass in 1993 but showed slight differences in cover the following spring.

Violets (*Viola* spp.) had the second highest biomass inside the exclosure, but outside the exclosure, they ranked third and had approximately one third the biomass and a similar frequency (Table 3). Both maple and spring beauty had considerably lower frequencies outside the fence. These data indicate differences in deer browse pressures on the various herbaceous species, but our sample size was too small to distinguish a hierarchy of species preferences by the deer.

Summer's Pond is dominated by grasses and tall goldenrod, and no significant difference existed between biomass values for plots inside and outside the exclosure. McCaffery, *et al.* (1974) state that graminoids and evergreen ground cover are the most important deer browse in northern Wisconsin during spring and are second in summer. Sotala and Kirkpatrick (1973) examined the rumen contents of deer in southern Indiana, and their data showed that grass was important in the spring and winter, and goldenrod was utilized in the spring and summer. Our biomass data indicate no deer damage to the graminoids at this site. The only difference between plots inside versus outside the fence was the larger amount of goldenrod inside. Goldenrod is a colonial species, and large colonies do occur outside the fence but not in the sample area.

CONCLUSIONS

The forested habitat, Swamp Rose, showed significant impact of deer browse on the vernal flora. Ten small biomass samples showed significant differences in biomass between plots outside a deer exclusion fence and plots inside the fence. *Acer* sp. and *Claytonia virginica* showed the greatest impact with *Viola* sp. and *Dicentra* sp. showing some impact. Ten samples are not sufficient to determine deer browse species preferences based on biomass or cover differences inside and outside the fenced area. Biomass is a more sensitive indicator of grazing impacts, and ten cover samples are sufficient to monitor changes in major species' abundance and composition.

The old field site, Summer's Pond, which is dominated by grasses, failed to show any significant differences between the fenced and unfenced study plots.

If a goal of the Park is to "preserve outstanding examples of Indiana's natural, historic, and scenic heritage," then special attention must be placed on identification and continued monitoring of the impacted plant species within the Park. Jones, *et al.* (1993) showed that songbirds and forest regeneration are greatly affected at deer densities much lower than the present one at Potato Creek. Potato Creek

State Park and adjacent areas possess ideal deer habitat capable of producing large deer populations which may lead to the eventual loss of many wildflower species and song birds. The Park's native biota should be monitored closely in the coming years so that proper management strategies can be developed to maintain its biodiversity. Monitoring of the herbaceous layer can be done with properly designed cover studies that are less destructive than biomass studies.

ACKNOWLEDGMENTS

The authors thank Gerald Pagac, Director of State Parks, for permission to collect biomass samples in the Potato Creek State Park deer exclosure plots. Our sincere appreciation also goes to David Clute and Linda Matzat of Potato Creek State Park, who assisted in cover data collection, and to the anonymous reviewers of this manuscript for their helpful comments and suggestions.

LITERATURE CITED

Cordell, T. 1992. Potato Creek State Park's deer exclosure study: A preliminary report. Potato Creek State Park Rep., Indiana Dep. Natur. Res., Div. State Parks, Indianapolis, Indiana, 19 pp.

Girard, G.T., B.D. Anderson, and T.A. De Laney. 1993. Managing conflicts with animal activists: White-tailed deer and Illinois nature preserves. Natur. Areas. J. 13: 10-17.

Indiana Division of State Parks. 1976. Environmental impact assessment, Potato Creek Recreation Area. Indiana Dep. Natur. Res., Indianapolis, Indiana, 18 pp.

_____. 1983. Indiana State Parks policy manual, Sec. 103-2. Indiana Dep. Natur. Res., Indianapolis, Indiana, 889 pp.

Jones, L.L. 1993. Deer counted at park. South Bend Tribune, 14 March, C7.

Jones, S.B., D. deCalstra, and S.E. Chunko. 1993. Whitetails are changing our woodlands. Amer. Forests 99: 20-25, 53-54.

Kelly, T.M. and R.C. Anderson. 1993. Influence of white-tailed (*Odocoileus virginianus*) deer browsing on biomass production and reproductive effort of herbaceous flora in a central Illinois hardwood forest. Bull. Ecol. Soc. Amer. 74(2, Suppl.): 304 (abstr.).

McCaffery, K.R., T. Tranetzki, and J. Piechura, Jr. 1974. Summer foods of deer in northern Wisconsin. J. Wildl. Manage. 38: 215-219.

Miller, S.G., S.P. Bratton, and J. Hadidian. 1992. Impacts of white-tailed deer on endangered and threatened vascular plants. Natur. Areas J. 12: 67-74.

Porter, W.F. 1991. White-tailed deer of eastern ecosystems. Natur. Res. Rep., US Dep. Interior, Nat. Park Serv., Denver, Colorado, NPS/NRSUNY/NRR-91/05, 57 pp.

Sotala, D.J. and C.M. Kirkpatrick. 1973. Foods of white-tailed deer, *Odocoileus virginianus,* in Martin County, Indiana. Amer. Midl. Natur. 89: 281-286.

Strole, T.A: and R.C. Anderson. 1992. White-tailed deer browsing: Species preferences and implications for central Illinois forests. Natur. Areas J. 12: 139-144.