The Effects of Deer Browsing on Forest Regeneration in Black Rock Forest

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Introduction

Browsing by a variety of mammals, particularly by the white-tailed deer, *Odocoileus virginianus*, has been shown in numerous studies to inhibit regeneration of browse-sensitive tree species and to alter the nature of forest regrowth patterns. (Alverson *et al.*, 1988; Anderson and Katz, 1992). Fenced exclosures are frequently installed to study the impacts of mammal browsing or to enhance forest regeneration. (find citation or just use multiple studies in which exclosures were installed see S/collin/papers)

Two exclosures were installed at Black Rock Forest in Cornwall, New York, the first in 1971 and the other in 1988. A large area located on the East side of Sutherland Pond Road approximately 55 meters south of the intersection with Hall Road was clear-cut in 1971. At this time, a small exclosure measuring 2.44m x 3.66m (8' x 12') was constructed within this clear-cut area; however, most of the clear-cut has remained unexclosed for the past 33 years. Conifers (white pine, scotch pine, Austrian pine, and white spruce) were planted in the clear-cut area in 1976. Some of the planted trees were fenced to prevent browsing. Very few mature conifers are found in the area today. No other data exists on the outcome of these plantings (Black Rock Forest, Compartment File XXV).

The second exclosure, established in 1988, is located on the south side of Sutherland Pond Road immediately east of the intersection with Hall Road and directly north of the 1971 clear-cut area. A particularly severe gypsy moth invasion in 1986 destroyed a swath of canopy trees in and around this site (BRF Compartment File VIII). Both dead and living trees were cleared from the area in 1988 prior to construction of the second exclosure. The exclosure received substantial seed input: numerous plantings were attempted and several surviving oak

trees were left along the edge as a seed source. As of May 1989, the exclosure contained a total 148 trees, including *Juglans nigra & cinera, Quercus rubra, Picea glauca, Quercus alba, Quercus montana*, and *Pinus sylvestris*. The area was weeded and treated with Round-Up to release the seedlings from competition with weeds (BRF, Compartment XXV). While there is no more information on the outcome of these plantings, Forest Manger John Brady stated that virtually none of the planted trees reached maturity.

The 1988 Hall Road deer exclosure was last surveyed in 1999 by Jamie Ballantyne. Ballantyne recorded significantly higher basal areas within the 1971 and 1988 exclosures than in the unfenced control area (Ballantyne 1999). Approximately half of the original 1988 fencing was removed in the summer of 1999 after completion of Ballantyne's survey, creating a new treatment area (exclosure-out).

In this study we have followed-up on Ballantyne's 1999 vegetation surveys. Because the 1988 exclosure was initially intended as a forest management tool - not a scientific experiment - no control plot was mapped out at that time. We therefore identified, created, and surveyed a similarly treated unexclosed control area to which regeneration rates within the 1988 exclosure area and the 1971 clear-cut are compared. This area received similar treatment to the exclosure but was not subject to the clearing applied to the exclosure area in 1988 after the gypsy moth invasion. Several of the largest canopy trees were removed, but no living trees were cut down.

Methods

The vegetation compositions of four different areas were included in this study: the remaining section of the 1988 exclosure (1988 exclosure-in), the area from which fencing was removed in 1999 (1988 exclosure-out), an unexclosed control plot on the opposite side of

Sutherland Pond Road (2004 control), and the 1971 clear-cut area (1971 clear-cut). Two of those areas, 1988 exclosure-in and 1988 exclosure-out, were surveyed using the six study plots – three in each area – that Ballantyne established in 1999. Six new plots were randomly established and surveyed within the 2004 control area. An additional six plots were randomly established in the 1971 clear-cut area. Ballantyne initially used the entire 1971 clear-cut area as a control for both the 1971 exclosure and the 1988 exclosure. Instead of surveying the entire clear-cut area, we used the six new plots as an approximate control for the treated areas. We did not include the 1971 exclosure in our results because the enclosed area is of insufficient size to make relevant comparisons.

A 3.58m (11.77') rope was fastened to each post to form the radius of a .00405 hectare plot ($1/100^{th}$ acre). For trees greater than 2.54 cm (1") diameter at breast height (DBH) within the plot area, height and DBH were recorded. The presence of damage consistent with deer rubs was also noted. Trees with DBH below 2.54cm were counted and termed "saplings" for the purpose of this study. Coverage of other types of vegetation (shrubs, forbs, grasses, ferns, moss, and trees) was estimated and recorded on the Braun-Blanquet scale (appendix 1) at three elevation levels: below 1 meter, 1-2 meters, and above 2 meters. A species list was compiled and coverage for each species was similarly estimated and recorded.

Because one plot within the control area contained an atypically large red oak (DBH = 41.3cm) that predates any treatment, an additional group was created excluding this tree – "control without outlier." The sample basal area of the plot containing the large red oak was 52.67, more than five times larger than any other sample basal area within the control plot. This study attempts to approximate a control plot because none were created at the time the exclosure

was constructed. Large trees such as this oak that predate any treatment are not meaningful in comparison with an area that was entirely clear-cut just 16 years ago.

Results

Plot	In	Out	Control	Control w/o outlier	1971 clear
1	10.33	7.88	8.21	8.21	0
2	21.34	8.13	9.97	9.97	0
3	10.84	15.58	9.61	9.61	0
4			0	0	0
5			52.67	2.61	0
6			2.61		0
MEAN	14.17	10.53	13.85	6.08	0
95% CI	14.17 +/- 15.0	10.53 +/- 7.44	13.85 +/- 6.3	6.08 +/- 5.59	

Table A: Basal Areas (m^2/ha) per plot and mean values per treatment area.

	1988 In	1988 Out	Control	Control w/o outlier	1971 clear
1988 In	x	0.45	0.98	0.074	*0.00053*
1988 Out	0.45	x	0.79	0.22	*0.00038*
Control	0.98	0.79	x	x	0.11
Control w/o outlier	0.074	0.22	x	x	*0.0086*
1971 clear	*0.00053*	*0.00038*	0.11	*0.0086*	x

Table B: P-values testing statistical significance between sample basal areas. Italicized P-values indicate significance (P<.05)

	Total			OAK		
	BA (m2/hec)	D (trees/hec)	Ht (m)	BA	D	Ht
1988 Exclosure "In"	14.2	4859.7	8.9	0.8	329.5	7.6
1988 Exclosure "Out"	10.5	3953.7	9.1	0.1	82.4	3.9
1988 Exclosure "All"	12.4	4406.7	9.0	0.4	205.9	5.8
1971 Clear-cut	0.0	0.0	0.0	0.0	0.0	Na
Control Forest	13.9	700.1	10.5	6.0	82.4	20.0
	RM			Birch		
	BA	D	HT	BA	D	Ht
1988 Exclosure "In"	0.0	0.0	na	11.8	4365.5	8.9
1988 Exclosure "Out"	0.0	0.0	na	8.1	3377.1	9.3
1988 Exclosure "All"	0.0	0.0	na	9.9	3871.3	9.1

1971 Clear-cut	0.0	0.0		0.0	0.0	Na
Control Forest	5.9	453.0	12.6	1.2	82.4	12.3

Table C: Basal Area, Tree Density, and Average Height by species per treatment area.

	Total		OAK		RM	
	Below	Above	Below	Above	Below	Above
1988 Exclosure "In"	5353.9	2223.9	2059.2	82.4	3047.6	0.0
1988 Exclosure "Out"	6342.4	2553.4	906.1	82.4	4612.6	1070.8
1988 Exclosure "All"	5848.2	2388.7	1482.6	82.4	3830.1	535.4
1971 Clear-cut	5477.5	41.2	2471.1	0.0	1894.5	0.0
Control Forest	11861.0	0.0	7701.4	0.0	4036.1	0.0
	Birch		Other			
	Below	Above	Below	Above		
1988 Exclosure "In"	164.7	2141.6	82.4	0.0		
1988 Exclosure "Out"	494.2	1235.5	329.5	164.7		
1988 Exclosure "All"	329.5	1688.6	205.9	82.4		
1971 Clear-cut	906.1	41.2	205.9	0.0		
Control Forest	82.4	0.0	41.2	0.0		

Table D: Tree density (trees per hectare) above or below-breast by treatment area and species.

The 6 plots within the 1971 clear-cut area contained no trees with DBH > 2.54cm, resulting in a mean basal area of 0. The exclosure-in had a mean basal area of 14.17 m^2/ha, greater than the exclosure-out (10.53 m^2/ha), the control (13.85 m^2/ha), and the control without outlier (6.08 m^2/ha). (*Table A)* Comparisons between the basal areas of the 1971 clear-cut and the other treatment areas were significant: exclosure-in vs. 1971 clearcut ($P < .001$), exclosure-out vs. 1971 clearcut ($P < .0005$), control w/o outlier vs. 1971 clearcut ($P < .01$). No other comparisons were significant. (*Table B*)

Black and yellow birch constituted nearly all of the basal area in exclosure-in and exclosure-out. (*Table C*) In the control forest, most of the basal area consisted of oak and red maple; only a small amount of birch was present. (*Table C*) The 1971 clear-cut contained no trees large enough to factor into basal area calculations.

No above breast height saplings were found in the 1971 clear-cut or in the control forest. The exclosure-in and exclosure-out each contained more than 2,000 above breast height individuals/ha (*Table D*). The exclosure-in contained a lower density of above breast height saplings than the exclosure-out (2,223.9: 2,553.4 individuals/ha). Below breast height saplings were found in all four stands. The control forest had a density of 11,861 individuals/ha, nearly twice that of the other stands (*Table D*).

Conclusion

Although the 1988 exclosure-in appears to have a higher mean basal area than the exclosure-out (from which fencing was removed in 1999), the difference in the means is not statistically significant ($p=0.45$). This may be due to the short time span since the fencing was removed and the outside area became again subject to browsing and buck damage. The higher mean basal area in the exclosure-in (14.17 m^2/ha vs. 10.53 m^2/ha) suggests better regeneration in the fenced area. No trees within the exclosed area were damaged by buck rubs, while 19% (10 of 48) of the trees in exclosure-out were damaged. The areas should be closely observed because this damage may contribute to increasingly disparate basal areas in the future. More than 5 years of differential treatment will be required; future surveys are recommended.

In exclosure-in and exclosure-out, the number of trees per hectare is proportional to the basal areas and the average height of the trees is very similar (*Table C*). These data suggest that regeneration patterns are similar in exclosure-in and exclosure-out. The nearly identical species composition of these two plots reinforces this idea. Contrary to expectations, more above-breast height saplings were counted in exclosure-out than in exclosure-in. At this time, just 5 years

after removal of the fence, it is impossible to say whether or not the remaining exclosed area is faring better or worse than exclosure-out.

Below breast height seedlings were found abundantly in all four stands surveyed, but the exclosure-in and exclosure-out were the only stands with any above breast height saplings (*Table E*). This suggests that while there are seed sources available and saplings persistently sprout each year, without the protection of fencing they do not grow above breast height. In fact, the control forest, with an oak canopy had even more seedlings than the other stands.

The most significant finding comes from comparisons between exclosure-in and exclosure-out with the 1971 clear-cut area. The clear-cut area has never been protected by fencing from deer browsing. Over the past 33 years, not a single tree has reached 2.54 cm DBH; the basal area remains zero. While both exclosure-in and exclosure-out have grown into lively birch stands, interspersed with several other species, the adjacent 1971 clear-cut area has grown into a dense, treeless blueberry patch. The difference in basal areas is very strongly significant. These data strongly support the hypothesis that deer browsing is effectively inhibiting forest regrowth in Black Rock Forest.

Appendix I: Species Recorded

Category	Designation	Common Name	Scientific Name
TREES			
	BB	black birch	*Betula lenta*
	YB	yellow birch	*Betula alleghaniensis*
	TP	tulip poplar	*Liriodendron tulipifera*
	BC	black cherry	*Prunus serotina*
	WO	white oak	*Quercus alba*
	RO	northern red oak	*Quercus rubra*
	RM	red maple	*Acer rubrum*
	BO	black oak	*Quercus velutina*
	HAW	hawthorn	*Crataegus macrosperma*
	SB	shadbush	*Amelanchier arboria*

	GB	gray birch	*Betula populifolia*
	AP	austrian pine	*Pinus resinoso*
	BTA	big-toothed aspen	*Populus grandidentata*
	WA	white ash	*Fraxinus americana*
SHRUBS			
	HBBlue	high bush blueberry	*Vaccinium corymbosum*
	LBBlue	low bush blueberry	*Vaccinium angustifolium*
	MLV	mapleleaf viburnum	*Viburnum acerifolium*
	DEW	bristly dewberry	*Rubus hispidus*
	WITCH	witch hazel	*Hamamaelis virginiana*
	WG	wintergreen	*Gaultheria procumbens*
	BLKBerry	blackberry	*Rubus allegheniensis*
	STPL	steeple bush	*Spiraea tomentosa*
	MEADSW	meadow sweet	*Spiraea alba*
FERN			
	HSF	hay-scented fern	*Dennstaedtia punctilobula*
FORBS			
	TS	twisted stalk	*Streptopus roseus*
	CM	canada mayflower	*Maianthemum canadense*
	GR	golden rod	*Solidago sp.*
	EN	enchanted nightshade	*Circea leuteum*
	LQ	whorled loosestrife	*Lysimachia quadrifolia*
	IC	indian cucumber	*Medeola virginiana*
	SW	striped wintergreen	*Chimaphilla maculata*
	PI	poison ivy	*Toxicodendron radicans*
	FSS	false solomons seal	*Smilacina racemosa*
	COW	cow wheat	*Melampyrum lineare*
	SF	sweet fern	*Comptonia peregrina*

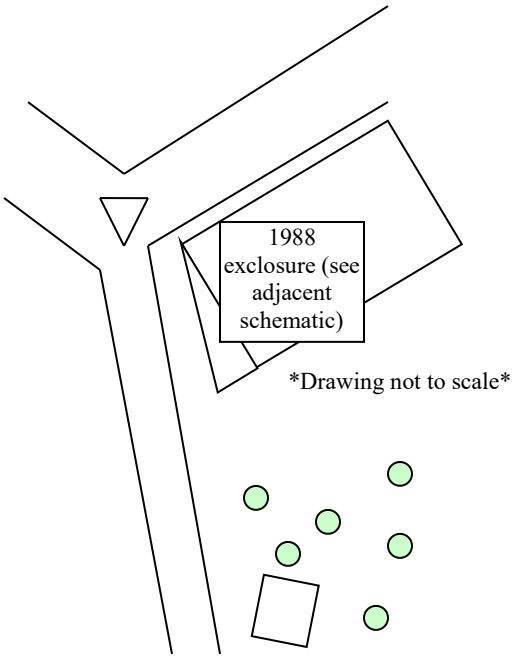

Figure 1. Schematic map of 1971 Exclosure in the Black Rock Forest.

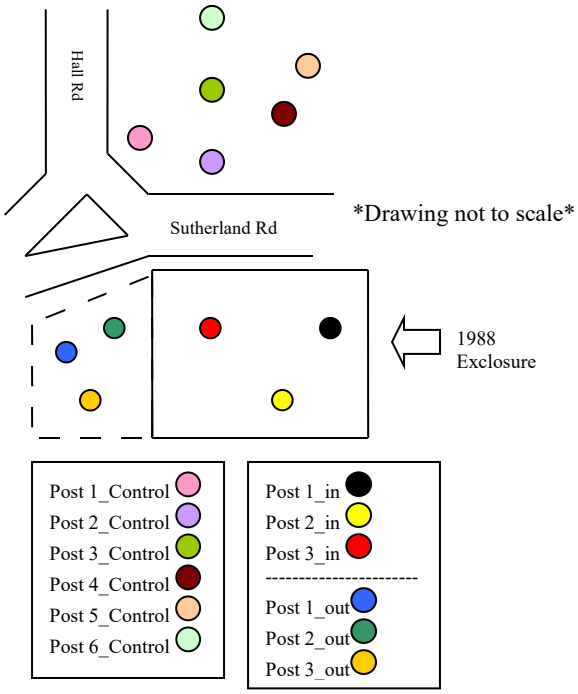

Figure 2. Schematic map of 1988 Exclosure and Control in the Black Rock Forest.