Red Elderberry (Sambucus racemosa) and Red Maple (Acer rubrum) Absolute Growth Rates in the presence of white-tailed deer (Odocoileus virginianus) herbivory and canopy gaps

BIOS 35502-01: Practicum in Field Biology

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Abstract

White-tailed deer populations have been increasing for the last century, after near extirpation. Populations have never been as high as they are now. Deer are herbivores, browsing preferentially on woody and herbaceous species. Red Maple and Elderberry are two of these species that are preferred by deer. We test the Absolute Growth Rate (AGR) for these species with and without deer exclusion cages and in intact forest vs. canopy gaps. We found that the AGR is highest for caged individuals and is generally not affected by the presence of canopy gaps. However, we found that Elderberry at the Plum Lake site grew significantly more in the gap than in the intact forest.

Introduction

White-tailed deer populations in the Northern Hardwoods Forest have rebounded immensely since being nearly extirpated in the early 1900's (Horsley et al. 2003 and QDMA, 2011) With an overabundance of deer comes vast over-browsing of woody species. This causes large declines in both the abundance and diversity of these species(Pendergast et al, Kain et al). Pre-settlement white-tailed deer density estimates are 3.1-7.7/km². This is much lower than present day estimates of 7.7-14.8/km² in heavily forested areas and up to 60/km² in areas of forest mixed with agricultural land (Seton 1953, Severinghaus 1955, McCabe 1984) The Michigan DNR found a deer population of 2.1/km^2 in Gogebic County surrounding the UNDERC property. In this experiment we will explore whether or not deer exclusion cages and canopy gaps affect the AGR of Red Maple and Elderberry. We will test the null hypothesis that the AGR of these species will not be affected deer exclusion cages and the presence of canopy gaps.

Methods & Materials

To test the hypothesis we located three blowdown sites that occurred during the same storm in the summer of 2016. The surface area of each blowdown was calculated using a handheld gps. For 2 blowdown plots we made a plot of the same area, in a random direction, within the intact

forest. This left us with 3 blowdown plots and 2 intact forest plots for a total of 5. Each plot was divided into a grid of 10 subplots of the same area. The total number of individual red maple and elderberry seedlings and saplings under 150cm (centimeters) were counted and numbered with flagging. The lone blowdown plot lacked red maple and lacked both species in the surrounding intact forest, so the AGR was only calculated for caged and uncaged elderberries within the blowdown. We then randomly selected one individual in each plot to receive a deer exclusion cage and one individual as a control. This left us with 10 individuals of each species in every plot with a deer exclusion cage and 10 individuals as controls.

The deer exclusion cages were constructed from wire poultry fencing stapled to a wooden fence post. The cages were 122 cm tall and had a diameter of 60 cm. The cages were built tall enough to inhibit deer from browsing the plant and wide enough as to not affect its natural growth.

One set of two plots, a blowdown and its replicate in intact forest, were done in one day with all 5 plots done in 3 consecutive days. Initial height measurements were done on the same day as caging. The cages and controls were left out for 4 weeks. After the 4 weeks, the cages were removed over 3 consecutive days in the same order they were put up. The final plant heights were recorded upon removal of the cages. The absolute growth rate (AGR) was calculated using the formula: $Height_{Final} – Height_{Initial}$

Results

The AGR for caged individuals was significantly higher than uncaged individuals in every plot and for both species. See AGR relative to both variables in Figures 5-12. The p-value for caged vs. uncaged Red Maple at Plum Lake was 0.00000004, mean squares of 5.32455625*

E^{+3} with df= 1,36 and a F-ratio of 47.55758309. The p-value for Red Maple located in the gap vs. intact at Plum Lake was 0.59698987, mean squares of 31.86225 with df= 1,36 and a F-ratio of 0.28458552. The interaction between caged vs. uncaged and gap vs. intact gave a p-value of 0.93259406, mean squares of 0.81225 with df= 1,36 and a F-ratio of 0.00725481. The error for Red Maple at Plum Lake was df= 36 and mean square of 111.96019444. A Tukey's Honestly-Significant-Difference Test was ran for a post hoc. It revealed where the significance was in the data. See Figure for details.

The p-value for caged vs. uncaged Red Maple at Craig House was 0.00000982, mean squares of 358.20225 with df= 1,36 and a F-ratio of 26.40911632. The p-value for Red Maple located in the gap vs. intact at Craig House was 0.88139622, mean squares of 0.30625 with df= 1,36 and a F-ratio of 0.02257884. The interaction between caged vs. uncaged and gap vs. intact gave a p-value of 0.32794715, mean squares of 13.34025 with df= 1,36 and a F-ratio of 0.98353434. The error for Red Maple at Craig House was df= 36 and mean square of 13.56358333. A Tukey's Honestly-Significant-Difference Test was ran for a post hoc. It revealed where the significance was in the data. See Figure for details.

The p-value for caged vs. uncaged Elderberry at Plum Lake was 0.00000021, mean squares of 2.51412736* E^{+3} with df= 1,36 and a F-ratio of 40.88783028. The p-value for Elderberry located in the gap vs. intact at Plum Lake was 0.03922203, mean squares of 281.53636 with df= 1,36 and a F-ratio of 4.57869111. The interaction between caged vs. uncaged and gap vs. intact gave a p-value of 0.00074207, mean squares of 836.12736 with df= 1,36 and a F-ratio of 13.59813315. The error for Elderberry at Plum Lake was df= 36 and mean square of

61.48839333. A Tukey's Honestly-Significant-Difference Test was ran for a post hoc. It revealed where the significance was in the data. See Figure for details.

The p-value for caged vs. uncaged Elderberry at Craig House was 0.00000162, mean squares of 312.2015625 with df= 1,36 and a F-ratio of 32.78325741. The p-value for Elderberry located in the gap vs. intact at Craig House was 0.98173263, mean squares of 0.0050625 with df= 1,36 and a F-ratio of 0.0005316. The interaction between caged vs. uncaged and gap vs. intact gave a p-value of 0.26392306, mean squares of 12.2655625 with df= 1,36 and a F-ratio of 1.2879663. The error for Elderberry at Craig House was df= 36 and mean square of 9.52320139. A Tukey's Honestly-Significant-Difference Test was ran for a post hoc. It revealed where the significance was in the data. See Figure for details.

Discussion

The experimental results partially support the hypothesis - that Elderberry and Red Maple would have a higher AGR when in cages and within the canopy gap. Every individual, regardless of species, with a cage, had a higher AGR than those without a cage. Although individuals did not have a higher AGR within the gap compared to the intact forest with the exception of Elderberry at Plum Lake. The Elderberry at Plum Lake grew fastest with a cage and in the gap whereas Red Maple at Plum Lake and both species at Craig House grew similarly in the intact forest and the gap.

The post hoc test for Red Maple at Plum Lake revealed that the only significance was when a caged individual was compared to an uncaged individual. Whether or not the plant was in the gap or in intact forest was insignificant. See Figure 1 for more details. Red Maple at Craig House followed the same pattern as well. See Figure 2 for details.

The post hoc test for Elderberry at Plum Lake also revealed that the most significance was when a caged individual was compared to an uncaged individual and it showed significance for caged*gap compared to caged*intact. See Figure 3 for additional details. The Elderberry at Craig House only showed significance when a caged individual was compared to an uncaged one. See Figure 4.

These results show that white-tailed deer certainly have an impact on forest health. These are just two species present in the forest but there are hundreds of other woody and herbaceous species that deer preferentially browse. The deer are not killing the larger plants when browsing them but rather stunting their growth enough that they will never grow any taller with deer present. This can keep plants from reaching maturity and reproducing. It is incredibly rare to see Red Maple and Elderberry in the understory that have surpassed the browse line. White-tailed deer are a natural resource that need to be managed like any other. Without proper management we will fail to reverse the damage they've done and it will only get worse with time. We should take note of how Native American tribes manage their deer populations as the Ojibwa in Northern Wisconsin can hunt year round and have much more sustainable deer populations on the reservation which meant less deer browse and a healthier, diverse forest ecosystem(Waller et al).

Figures

Tukey's Honestly-Significant-Difference Test

CAGE*BLOWDOWN	CAGE*BLOWDOWN	Difference	p-Value	95% Confidence Interval	
				Lower	Upper
Caged*Gap	Caged*Intact	2.07000000	0.97158647	-10.67452063	14.81452063
Caged*Gap	Uncaged*Gap	23.36000000	0.00010766	10.61547937	36.10452063
Caged*Gap	Uncaged*Intact	24.86000000	0.00004347	12.11547937	37.60452063
Caged*Intact	Uncaged*Gap	21.29000000	0.00038840	8.54547937	34.03452063
Caged*Intact	Uncaged*Intact	22.79000000	0.00015338	10.04547937	35.53452063
Uncaged*Gap	Uncaged*Intact	1.50000000	0.98879055	-11.24452063	14.24452063

Fig. 1: Post hoc test for Red Maple at Plum Lake.

Tukey's Honestly-Significant-Difference Test

BLOWDOWN*CAGE	BLOWDOWN*CAGE	Difference	p-Value	95% Confidence Interval	
				Lower	Upper
Gap*Caged	Gap*Uncaged	7.14000000	0.00062725	2.70412905	11.57587095
Gap*Caged	Intact*Caged	1.33000000	0.85047636	-3.10587095	5.76587095
Gap*Caged	Intact*Uncaged	6.16000000	0.00342675	1.72412905	10.59587095
Gap*Uncaged	Intact*Caged	-5.81000000	0.00613438	-10.24587095	-1.37412905
Gap*Uncaged	Intact*Uncaged	-0.98000000	0.93293312	-5.41587095	3.45587095
Intact*Caged	Intact*Uncaged	4.83000000	0.02840288	0.39412905	9.26587095

Fig. 2: Post hoc test for Red Maple at Craig House.

Tukey's Honestly-Significant-Difference Test

BLOWDOWN*CAGE	BLOWDOWN*CAGE	Difference	p-Value	95% Confidence Interval	
				Lower	Upper
Gap*Caged	Gap*Uncaged	7.14000000	0.00062725	2.70412905	11.57587095
Gap*Caged	Intact*Caged	1.33000000	0.85047636	-3.10587095	5.76587095
Gap*Caged	Intact*Uncaged	6.16000000	0.00342675	1.72412905	10.59587095
Gap*Uncaged	Intact*Caged	-5.81000000	0.00613438	-10.24587095	-1.37412905
Gap*Uncaged	Intact*Uncaged	-0.98000000	0.93293312	-5.41587095	3.45587095
Intact*Caged	Intact*Uncaged	4.83000000	0.02840288	0.39412905	9.26587095

Fig. 3: Post hoc test for Elderberry at Plum Lake.

Tukey's Honestly-Significant-Difference Test

BLOWDOWN*CAGE	BLOWDOWN*CAGE	Difference	p-Value	95% Confidence Interval	
				Lower	Upper
Blowdown*Caged	Blowdown*Uncaged	6.69500000	0.00013806	2.97808040	10.41191960
Blowdown*Caged	Intact*Caged	1.13000000	0.84519861	-2.58691960	4.84691960
Blowdown*Caged	Intact*Uncaged	5.61000000	0.00137005	1.89308040	9.32691960
Blowdown*Uncaged	Intact*Caged	-5.56500000	0.00150390	-9.28191960	-1.84808040
Blowdown*Uncaged	Intact*Uncaged	-1.08500000	0.86022981	-4.80191960	2.63191960
Intact*Caged	Intact*Uncaged	4.48000000	0.01291858	0.76308040	8.19691960

Fig. 4: Post hoc test for Elderberry at Craig House.

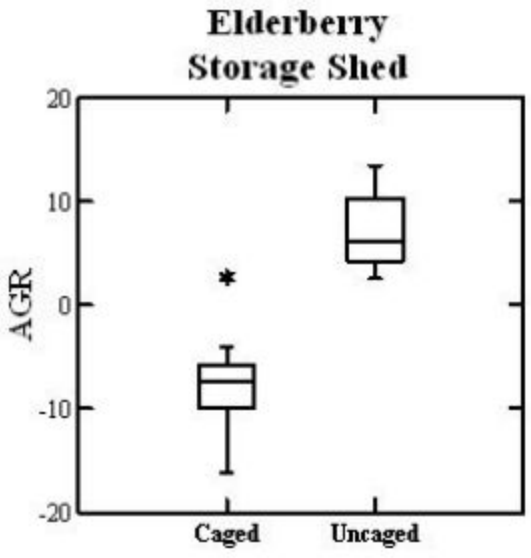

Fig. 5: Elderberry AGR at the Storage Shed blowdown.

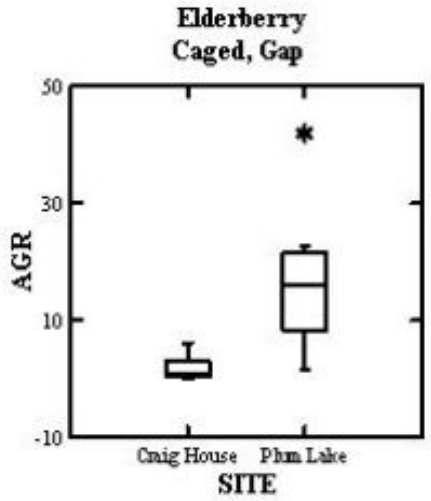

Fig. 6: AGR of caged Elderberry within the canopy gap at each site.

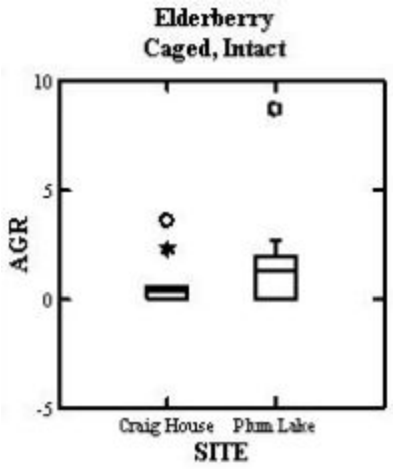

Fig. 7: AGR of caged Elderberry within the intact forest at each site.

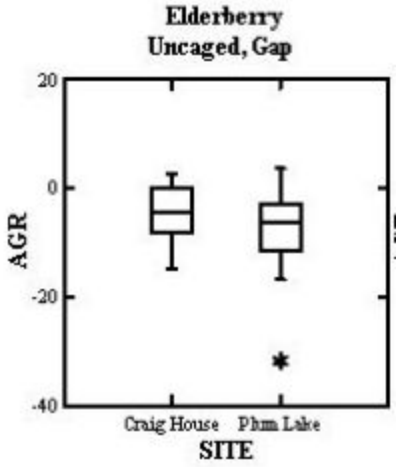

Fig. 8: AGR of uncaged Elderberry in the canopy gap at each site.

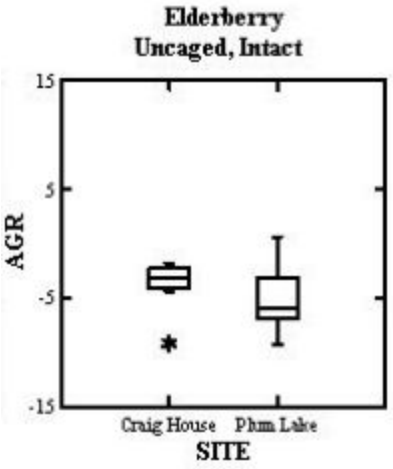

Fig. 8: AGR of uncaged elderberry within the intact forest at each site.

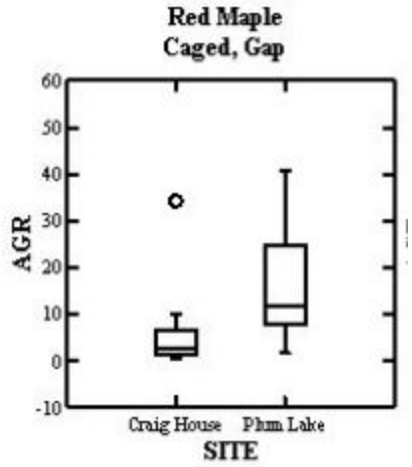

Fig. 9: AGR of caged Red Maple in the canopy gap at each site.

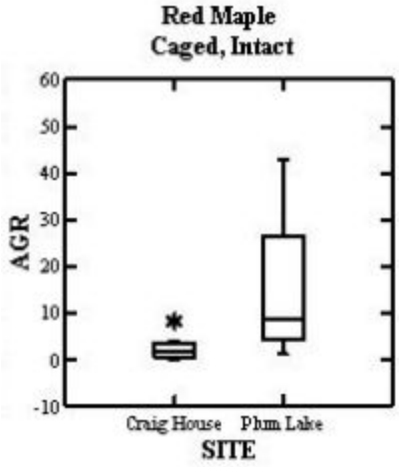

Fig. 10: AGR of caged Red Maple within the intact forest at each site.

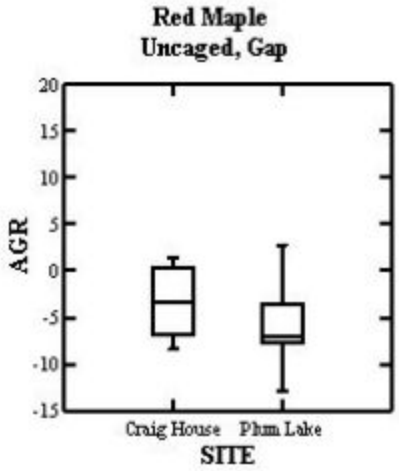

Fig. 11: AGR of uncaged Red Maple within the intact forest at each site.

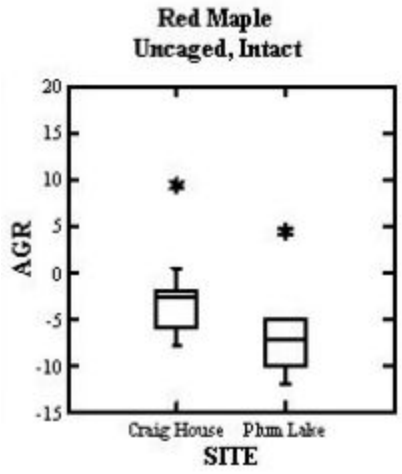

Fig. 12: AGR of uncaged Red Maple within the intact forest at each site.

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Literature Cited

Seton, E. T. 1953. White-tailed deer. Pages 229–307 in Lives of game animals. Volume 3, Part 1. C. T. Branford Company, Boston, Massachusetts, USA.

Severinghaus, C. W., and H. F. Maguire. 1955. Use of age composition data for determining sex ratios among adult deer. New York Fish and Game Journal 2:242–246.

McCabe, R. E., and T. R. McCabe. 1984. Of slings and arrows: an historical retrospection. Pages 19–72 in L. K. Hall, editor. White-tailed deer: ecology and management. Stackpole Books, Harrisburg, Pennsylvania, USA.

McCabe, T. R., and R. E. McCabe. 1997. Recounting whitetails past. Pages 11–26 in W. J. McShea, H. B. Underwood, and J. H. Rappole, editors. The science of overabundance: deer ecology and population management. Smithsonian Institution Press, Washington, D.C., USA

D. Waller, and N. Reo. First stewards: Ecological outcomes of forest and wildlife stewardship by indigenous people of Wisconsin, USA. *Ecology and Society* 23 (1)2018: 45-60.

T. Pendergast IV, S. Hanlon, Z. Long, A. Royo, and W. Carson. The legacy of deer overabundance: Long-term delays in herbaceous understory recovery. *The Canadian Journal of Forest Research* 462015: 362–69.

M. Kain, L. Battaglia, A. Royo, and W. Carson. Over-browsing in Pennsylvania creates a depauperate forest dominated by an understory tree: Results from a 60-year old deer exclosure. *Journal of the Torrey Botanical Society* 138 (3)2011: 322–26.

T. Nuttle, A. Royo, M.B. Adams, and W. Carson. Historic disturbance regimes promote tree diversity only under low browsing regimes in eastern deciduous forest. *Ecological Society of America* 83 (1)2013: 3–17.

Management guidance for deer management unit 127. *Michigan DNR*. 2017. http://www.michigandnr.com/Publications/pdfs/wildlife/dmu_info/DMU_127.pdf.