Predator-Mediated Effects on Deer Browsing Behavior

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Abstract

Overbrowsing by white-tailed deer (*Odocoileus virginianus*) is driving a loss of diversity and change in successional patterns in temperate forests throughout the nothern United States. Herbivore dynamics can be shifted through predator reintroduction, leading to fear-based modifications of herbivore behavior. In this experiment, white-tailed deer browsing behavior in areas of high and low use by wolves (*Canis lupus*) was compared using samples of big leaf aster (*Eurybia macrophylla*). Browsing pressure was expected to be less intense in areas of high wolf use, but no conclusive evidence was gathered for this hypothesis. Future studies should use a longer temporal span and a minimally intrusive design to increase the likelihood of deer response to the phytometer.

Introduction

In the past century, white-tailed deer (*Odocoileus virginianus*) have become one of the driving forces of change in North American forest ecosystems (Cote *et al.* 2004, Bressette *et al.* 2012). Through the absence of top-down control of predators such as the Eastern gray wolf (*Canis lupus*), white-tailed deer have become over-abundant in many areas (Cote *et al.* 2004, Bressette *et al.* 2012). Large white-tailed deer populations have been shown to reduce plant cover and diversity, significantly alter nutrient cycling, and change succession patterns throughout forest ecosystems (Balgooyen and Waller 1995, Rooney and Waller 2003, Cote *et al.* 2004, Tanentzap *et al.* 2012). Although white-tailed deer are generalist herbivores, they do exhibit preference for some species of woody and herbaceous plants and may drive some forb species to extirpation (Augustine and Frelich 1998, Fletcher *et al.* 2001, Ruhren and Handel 2003, Goetsch *et al.* 2011). For example, due to intense browsing pressure on the seeds and seedlings of many woody species, such as hemlock (*Tsuga canadensis*), oak (*Quercus* spp.), and white cedar (*Thuja occidentalis*), canopy tree regeneration has also been severely limited (Frelich and Lorimer 1985, Cote *et al.* 2004, Tanentzap *et al.* 2012). Over-browsing accompanied by shifts in forest composition toward browse and shade-tolerant species, such as sugar maple (*Acer saccharum*) and ferns (such as *Dennstaedtia punctilobula)*, may cause long-term effects to dominate forest ecosystem dynamics even after deer populations have been decreased (Frelich and Lorimer 1985, Rooney and Waller 2003, Goetsch *et al.* 2011).

Despite these lasting effects of deer browsing, the reintroduction of wolves and other predators to the northern United States has the potential to begin restoring forest ecosystems. Reintroductions have been shown to both decrease overall white-tailed deer abundance and change the behavior of deer populations (Brown *et al.* 1999; Ripple and Beschta 2003). When a predator-prey system is fear-driven, the prey often shifts its behavior, forgoing feeding opportunities in favor of increased time watching for predators, safer locations, and lower rates of overgrazing (Brown *et al*. 1999). In Yellowstone National Park, wolf presence-mediated effects have been shown to include greater vigilance and reduced browsing pressure from large elk populations on aspen and cottonwood (Ripple and Beschta 2003, Beschta and Ripple 2011). Fear-based behavioral changes may allow gradual regeneration of plant communities while herbivores are still present (Beschta and Ripple 2011).

For example, in northern Wisconsin, areas of high wolf use show up to 13 times less deer browse damage as areas of high wolf use using an index of sugar maple browse damage (SMBI) (D. Flagel, unpublished data). In places near human habitation, these extremes are seen in zones of high and low wolf use which are less than a mile apart (D. Flagel, unpublished data). This level of variability can be explained not only by the presence of wolves in the area, but also by the duration of time over which these differences have accumulated. Wolves were reintroduced to the Upper Peninsula of Michigan and northern Wisconsin in the early 1990's, allowing two decades of wolf-deer interactions to contribute to the patterns seen in the SMBIs (Michigan DNR 2012).

These differences in white-tailed deer browsing of a specific woody plant do not address whether woody and herbaceous species can regenerate in the presence of wolves. To help answer this, I hypothesized that *white-tailed deer would browse less heavily on reintroduced big leaf aster (*Eurybia macrophylla*) in areas of high wolf use than in areas of low wolf use.* Big leaf aster is a forb native to northern hardwood forests, though it is decimated across the study site in both high and low use areas. This can be explained by preferential feeding on big leaf aster by white-tailed deer (Mosbacher and Williams 2009, Ross *et al.* 1970, McCaffery *et al.* 1974). I expected that the number of plants browsed in each use area would illuminate the response of white-tailed deer to the presence of wolves in a way that would help predict the impact of wolf reintroduction on forest rehabilitation. Namely, I anticipated that fear-mediated effects would dominate white-tailed deer feeding behavior, causing less intense browsing pressure in areas more frequented by wolves, potentially allowing regeneration of native forbs in those areas.

Materials and Methods

This study was completed at the University of Notre Dame Environmental Research Center (UNDERC), a long-term research site in the Upper Peninsula of Michigan. UNDERC encompasses 6150 acres of land with an additional 1350 acres of wetland areas and bodies of water. The majority of the wooded areas at UNDERC are secondary growth northern mesic hardwood forests, dominated by sugar maple and hemlock; however, some early successional stands are also present. Access to the UNDERC property is tightly controlled causing it to be largely undisturbed.

In this experiment, areas of high and low wolf use on the UNDERC property were identified based on long-term observation. One hundred twenty potential sites were set up in both the high and low use areas, spaced 100-125m apart along the roads, at randomly generated distances into the woods (5-100m). Only wooded areas were sampled for the 240 main sites. Three additional sites were also established in areas without tree cover in each use area, split evenly between early successional and manually maintained areas.

Big leaf aster (*Eurybia macrophylla*) was used as the phytometer. All plants used were at least 10cm tall, with an average of 8 leaves and an average 39.5cm of total stem length per plant. They were grown from locally collected seeds at a commercial greenhouse. 24 sites in each use area were randomly selected. At each of site in this subset, a phytometer was staked between two and three feet off the ground to prevent damage from snowshoe hares and raccoons. Each plant was monitored daily for 5 days (June 27-July 1) immediately after having been set up, then every 7 days for 3 weeks (July 1–July 21). When a plant was browsed, the pot and stake were removed and another plant was set up at a different randomly generated site within the use area to maintain an even density of sites and prevent autocorrelation.

Two plants were also set up at each of the three open sites in each use area for one week (July 14-21) to increase sample size while maintaining the same site density. These more exposed locations also served as a control for the potential difficulty of finding the forest sites.

Results

Over the 4 weeks of the experiment, 2 sites were browsed. Both sites were located in the tree cover, high wolf use area and browsed within the week of July 2-7. They were at consecutive sites and similar distances into the woods from the road (30m and 33m). Because of this, autocorrelation between the non-natural set-up and the plant as food source may have led to browsing by the same individual deer.

None of the sites without tree cover were browsed. There was no evidence of browsing or damage by other mammalian herbivores.

Discussion

The results of this experiment are unable to assess the effect of wolf presence on the browsing behavior of white-tailed deer in the northern United States. Despite strong differences in the sugar maple browse indices in the high and low use areas surveyed and the findings from wolf reintroduction at Yellowstone National Park, deer were not shown to browse on big leaf aster at a lower intensity in areas frequented by wolves (D. Flagel, unpublished data; Ripple and Beschta 2003). This is also contrary to results anticipated by the tri-level trophic cascade hypothesis, which predicts that an increase in predators would result in increased plant fitness and abundance via decreased pressure from herbivores (Hairston *et al.* 1960). Instead, very little browsing was observed in both the high and low wolf use areas.

Nevertheless, the browsing of two sites in the high wolf area suggests the possibility of a different pattern. Following optimal foraging theory, if predation pressure was particularly intense, white-tailed deer might choose the highest nutrient foods available to maximize foraging efficiency, even if those foods are not as familiar. The big leaf aster plants used in this experiment were greenhouse grown in rich soil, increasing their nutrient content. Due to heightened senses of smell and taste, this amplified nutritional content would have been apparent to white-tailed deer. This pattern of optimized foraging, however, has not yet been observed in other studies, and the limited browsing seen here is unable to conclusively support this interpretation.

These limited results may be explained by the temporal constraints of this experiment and known white-tailed deer foraging behavior. As generalists, white-tailed deer are known to browse on a variety of plants. In midsummer there is no shortage of nutritious and easily available woody and forb species to which they are already accustomed. Despite documented preference for big leaf aster, the temporary set up of pots and stakes was unusual and not in place for a long enough time to be accepted and browsed by deer in either use area (Mosbacher and Williams 2009, Ross *et al.* 1970, McCaffery *et al.* 1974). The near extirpation of big leaf aster may have contributed to its present unfamiliarity to white-tailed deer. As large herbivores, white-tailed deer have evolved to elude predators such as wolves; this natural suspicion likely also limited their acceptance of the experiment sites.

In conclusion, more work is required to establish the relationship between the presence of wolves and the browsing behavior of white-tailed deer. Preferential foraging on big leaf aster makes it an ideal phytometer; however, it is clear that a more extended amount of time should be allotted. Future work with big leaf aster or a similar forb could contribute to the development of another phytometric tool to evaluate deer browsing intensity, such as those developed using sugar maple (*Acer saccharum*) damage and trillium (*Trillium grandiflorum*) height (Frelich and Lorimer 1985, Anderson 1994). Investigation of this relationship between wolves and deer with respect to forest herbs and woody species is essential to understanding, predicting, and managing the future of North American forests.

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