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Deer and diversity in Allegheny hardwood forests: managing an unlikely challenge

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Abstract

High white-tailed deer (*Odocoileus virginianus*) density and interfering vegetation were identified as factors affecting the regeneration of hardwood forests in the Allegheny National Forest and surrounding forests in northwestern Pennsylvania. Research was designed by Forest Service scientists to quantify these effects. A high degree of interest in the impact of these effects on the diversity of forest resources led to additional research. Scientists, natural resource managers, and private timber interests used the research findings on the impacts of deer and interfering vegetation on regeneration and diversity to produce newsletters, tours, symposia, and to make presentations to groups of legislators, environmentalists and other influential segments of the public. This combined research–educational effort has been associated with the enactment of hunting regulations designed to reduce deer density and for registration and continued use of herbicides to control interfering vegetation. Both actions have the potential to increase the diversity of songbirds and woody and herbaceous vegetation in forest lands. The challenge is to sustain directed management of deer density and interfering vegetation until these factors are controlled to the point where they no longer negatively impact the diversity of forest resources.

1. Introduction

The Allegheny National Forest (ANF) is located in northwestern Pennsylvania, and comprises approximately 250 000 ha of Allegheny hardwood, northern hardwood, and oak (*Quercus* sp.) types. It is the second largest piece of contiguous public land in Pennsylvania and the second largest national forest in the northeastern United States. Like other national forests, it is managed for multiple resources. It provides approximately one-third of the world's supply of cherry veneer and furniture wood and generates over 14 million dollars annually from timber receipts, special use permits, recreation fees, power and mineral fees, and administrative user fees. The ANF's abundant natural resources attract thousands of recreationists annually (335 000 recreation visitor-days in 1990) (Allegheny National Forest, 1990). Chief among these are hunters who harvested over 32 000 white-tailed deer in 1991 from the four-county area encompassing the ANF. In addition to its directive to manage for multiple resources, the ANF is charged to "provide for and maintain diversity of plant and animal communities to meet overall multiple-use objectives".

The ANF and its resources have changed since the land was developed by European settlement. With the exception of a few isolated patches of old growth forest, the ANF was almost completely logged in a sequence of partial cuts and clearcuts during the 1890–1930 railroad logging era in the northeast and in Pennsylvania (Braun, 1964; Marquis, 1975). As a result of this activity species were lost. Some of the native flora and fauna were eliminated, either deliberately, e.g. the mountain lion (*Felis concolor*) and the wolf (*Canis lupus*), or inadvertently, e.g. American chestnut (*Castenea dentata*), passenger pigeon (*Ectopistes migratorius*) and eastern elk (*Cervus elaphus canadensis*) (Schorger, 1955; Genoways,

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1985). The composition of overstory trees shifted from a climax mix of beech (*Fagus grandifolia*)–sugar maple (*Acer saccharum*)–hemlock (*Tsuga canadensis*) to an early to mid-successional mix of black cherry (*Prunus serotina*)–beech–red maple (*Acer rubra*) (Marquis and Gearhart, 1983). The oak type forest, a temporary type on the Allegheny Plateau created by disturbances such as fire, is shrinking as these disturbances are no longer common.

Prior to European settlement, which occurred in the ANF area about 1800, large-scale perturbations (windstorms and fire) produced large even-age blocks (thousands of hectares) of shade-intolerant tree species at infrequent intervals (100–300 years) (Borman and Likens, 1979). Smaller openings created in the forest by ice storms, local wind shear, and insect- and disease-induced mortality of individual trees comprised approximately 1% of the forest annually (Runkle, 1982). These patches of large and small openings created varying amounts of forage for deer and provided upper limits to deer density. Deer densities approaching these limits were dampened by pressure from abundant predators (American Indian, mountain lion, wolf) (Ellingwood and Caturano, 1988; Witmer and deCalesta, 1992).

This system of forage and predator influence on deer density was eliminated during the late 1800s as white settlers engaged in unregulated market hunting to meet a growing demand for meat in large cities and logging camps. White-tailed deer were nearly extirpated from Pennsylvania by the end of the 19th century (Marquis, 1975). Subsequent prohibition of hunting, elimination of natural predators, and creation of a vast abundance of deer forage by harvesting Pennsylvania's forests in the late 1800s and early 1900s resulted in a steep increase in the number of deer, beginning in 1907. Although the deer population has subsequently declined, the overall number of deer remains far above the density that existed prior to colonization (Witmer and deCalesta, 1992).

The heavy browsing pressure exerted by deer for approximately 70 years resulted in the loss or a reduced abundance of some woody species, shifts in species composition of understory vegetation, and failure of regeneration in areas with excessively high deer densities (Marquis and Brenneman, 1981; Whitney, 1984). Understory herbaceous vegetation and shrubs, including *Rubus* and witch hobble (*Viburnum alnifolium*), were nearly eliminated by deer and replaced by ferns and grasses (Hough, 1965; Horsley and Marquis, 1983; Whitney, 1984). When understories are dominated by grasses and ferns and high deer densities produce heavy browsing intensity, a diverse woody vegetation fails to become established (Horsley and Marquis, 1983), and future forests are characterized by low tree species diversity.

The demands of deer hunters (seeing as many deer as possible during the hunting season and high hunter success rates) can be met only when deer density is so high that vegetation damage becomes chronic.

These challenges to the preservation of diversity on the ANF are long-standing and were created in part by societal demands for forest resources (deer and timber) that run counter to maintaining diversity. The ecological relationships between these resources were incompletely understood by forest managers and those who influence and make decisions about the management of forest resources. This paper describes the association developed between natural resource scientists and managers to develop solutions to preserving diversity on the ANF.

2. Development of the research program

In 1979 the silvicultural research work unit (RWU-4152) of the USDA Forest Service Northeastern Forest Experiment Station designed a series of research projects to "develop and refine silvicultural practices required to establish and grow high quality hardwood for-

ests for timber and wildlife" on the Allegheny Plateau and Allegheny Mountain sections of Pennsylvania, New York, Ohio, and West Virginia.

Representatives from the USDA Forest Service, timber industry, Pennsylvania Game Commission, Pennsylvania Bureau of Forestry, regional universities, and New York State Conservation Department participated in the process of identifying major factors limiting the successful regeneration and yields of hardwood trees and designing appropriate research projects. High deer density and interference from woody and herbaceous vegetation were among the top priority items identified. A number of studies was established to determine the impacts of these independent variables on regeneration success. Because deer and interfering vegetation were later identified as factors potentially affecting the diversity of forest resources, evaluation of the impact of these factors on the diversity of forest resources was conducted.

3. Applied research projects

3.1. Impact of deer density on diversity

In 1979, a 10 year project was initiated to investigate the relationship between deer density and hardwood regeneration (Tilghman, 1989). Five different deer densities (0, 3.7, 7.9, 19.9 and 24.9 deer km^{-2}) were simulated within four replicate enclosed sites. Within each deer density enclosure, 10% of the area was clearcut, 30% thinned, and 60% left uncut to simulate intensive management to sustain timber yield on a 100 year rotation. The original dependent variable for this study was the success of hardwood regeneration as measured by regeneration stocking percentage, height growth, and maintenance of desirable woody species composition.

Increased interest and emphasis on management for diversity of forest resources prompted an 11th year evaluation of the impact of deer density on the diversity of forest vegetation, including woody and herbaceous vegetation, and wildlife communities, including songbirds and small mammals (deCalesta, 1992).

Results from this study indicated that deer density was negatively related to the success of hardwood regeneration, and diversity of woody and herbaceous vegetation and songbirds nesting in sapling- and pole-sized trees. The results also suggested that the threshold deer density where these effects became limiting was between 4 and 8 deer km^{-2}. At deer densities of over 8 deer km^{-2}, selective browsing by deer altered the species composition of woody and herbaceous vegetation so that plant–plant relationships changed, altering patterns of competition for resources among plant species and reducing the diversity of woody and herbaceous species (deCalesta, 1992).

3.2. Impact of interfering vegetation on diversity

Earlier studies suggested that ferns, grasses, striped maple (*Acer pennsylvanicum*), and beech can interfere with the regeneration of other woody plants, especially when high deer densities reduce the abundance of these woody plants (Horsley, 1977, 1981; Horsley and Bjorkbom, 1983; Horsley and Marquis, 1983). At sufficiently high levels of interference, desirable woody species do not become established in fully stocked conditions when overstory trees are removed by timber harvest. Instead, understocked stands of primarily undesirable woody and herbaceous species result.

Subsequent studies determined that the judicious use of herbicides could reduce herbaceous and woody plant interference sufficiently to permit the successful regeneration of desirable woody plants (Horsley, 1982; Horsley and Bjorkbom, 1983). The timing of application and lack of residual effect of herbicides prevented the exposure of forbs that flower in spring and early summer (Horsley, 1992). Because herbicides did not totally

eliminate target herbaceous and woody plants from treated sites, herbicide use actually increased the diversity of forest floor vegetation (Horsley, 1992).

The sum of these studies has been a qualitative and quantitative description of the impacts of deer and interfering vegetation on the diversity of woody and herbaceous vegetation and selected wildlife communities in hardwood forests on the Allegheny Plateau of western Pennsylvania. The studies were established as a direct result of the request for information about these impacts from practising foresters representing public and private forest lands. Implementation of the management steps required to mitigate these impacts on the diversity of forest resources required a concerted educational effort conducted by research and management personnel.

4. Applying research results

Applying the knowledge obtained from the studies required informing persons in positions of authority about the research implications and the consequences of acting on these results. A major effort was undertaken to educate these decision-makers concerning the management steps required to counteract the negative impacts of deer and interfering vegetation on forest resources and their diversity.

4.1. Deer management

A considerable body of knowledge concerning the impact of deer damage on vegetation uniformly concludes that the best, most cost-effective method for reducing deer damage is to reduce deer densities to levels that do not threaten the integrity of vegetative communities (Matschke et al., 1984; Ellingwood and Caturano, 1988; Witmer and deCalesta, 1992). Because deer impact wildlife communities indirectly via their impact on vegetation, the best way to lessen the negative impact of deer on wildlife communities is to reduce deer densities below levels where habitats are negatively impacted (McShea and Rappole, 1992; deCalesta, 1994).

A committee was formed by organizers of the deer research to educate and inform key decision-makers and influential action groups about the impacts of deer on forest resources. The goal of the committee was to "promote enactment of deer hunting regulations that will bring the deer herd down to target levels recommended by the Pennsylvania Game Commission, as these levels approximate densities associated with successful forest regeneration and maintenance of diversity of natural resources".

Committee members developed and disseminated a newsletter to persons considered influential in setting deer hunting regulations. Results from research developed by the committee, as well as research conducted by others, were summarized to promote the idea of deer herd reduction. Quantitative descriptions of the negative impact of high deer densities on commercial forestry and on the diversity of forest resources were included. Suggestions were aired on how deer hunting regulations could be managed to effect desired deer herd reductions.

Committee members conducted tours of research sites to demonstrate the negative impact of high deer density on forest resources. Decision-makers and special interest audiences were targeted as tour participants. Committee members testified before state senate and house committees that influenced decisions on deer harvest regulation. Committee members organized and conducted two large symposia that featured the results of studies of deer impact on forest resources. With these efforts, the committee obtained media coverage to spread further the message of deer impacts.

To enhance the efficiency of its message, the committee aligned itself with agricultural interests (another group affected by high deer density) to provide a united front that represented two large constituencies and considera-

ble portions of Pennsylvania's economy.

In 1989, pressurized by these groups to reduce deer density to its own target density (7 deer km^{-2} in the four-county area surrounding the ANF), the Pennsylvania Game Commission embellished its burgeoning antlerless deer harvest program by initiating a bonus tag system which allowed hunters to harvest an additional deer. Deer harvest, numbers of antlerless deer tags, and bonus tags increased in the succeeding 1990–1992 seasons and the density of the overwinter deer herd stabilized; previously it had been climbing steadily in spite of increased harvest. Recalculation of deer density for 1991–1992 by Pennsylvania Game Commission personnel suggested that it actually decreased by about 1.5 deer km^{-2} during 1990–1991 in the four-county area encompassing the ANF. If this declining trend in deer density can be maintained, by 1997 the density will approximate levels that research has identified as below the threshold for negative impact on diversity of forest resources.

It is unclear how long it will take (given that deer density can be kept at or below the target level) for woody and herbaceous vegetation to regain a measure of previous diversity. Preliminary results suggest that this period may be 10 years for woody vegetation (D.S. deCalesta, unpublished data, 1993; W. Healy, USDA Forest Service, personal communication, 1992). Unfortunately, herbaceous vegetation, particularly forbs, have much lower seed dispersal distances than trees, and unlike trees, no longer have adult individuals available to shed seed on many sites. Regaining the diversity of forbs may require several decades, during which time deer density is rigorously maintained at or below target density. Withstanding pressure from the hunting public to increase deer density during this period of diversity recovery will require sustained, unremitting effort by a coalition of impacted groups and enlightened, dedicated agency professionals.

4.2. Vegetation management

The proven efficacy of selected herbicides for the control of interfering vegetation, with no demonstrable negative environmental impacts, led to registration of these chemicals for use in forest management (Horsley, 1988). However, forest managers were confronted with a number of political challenges that could prevent such use of herbicides to improve diversity of forest vegetation. Some environmental groups threatened to file appeals against the Forest Service to challenge the use of herbicides in resource management; others actually did so.

Administrators from the ANF arranged for informal meetings among scientists, forest managers, and environmental groups where suits were pending. Administrators used vegetation management research to successfully rebut arguments of environmental groups in response to the Environmental Impact Statement concerning the use of herbicides.

As a result of the informal meetings, the environmental groups refrained from filing suits challenging the use of herbicides and the concerns of other environmental groups were successfully rebutted. The use of herbicides to control interfering vegetation on the ANF was successfully defended, and today the ANF selectively uses herbicides to control interfering vegetation. As a fortuitous result, the diversity of understory woody and herbaceous vegetation is being enhanced (Horsley, 1992).

5. Discussion

Deer density and interfering vegetation affect the diversity of woody and herbaceous vegetation and songbirds via impacts on composition, abundance, and structure of vegetation. It is important to recognize that both factors must be managed concurrently to optimize the diversity of forest resources. Without aggressive management, deer density and inter-

fering plants will increase at the expense of diversity of forest resources.

Attempts to educate decision-makers on the importance of controlling deer density and interfering vegetation have resulted in the retention of the use of herbicides to control interfering vegetation and modest reductions in deer density. Until deer densities reach target levels, considerable persuasion skills will be required to convince decision-makers to continue endorsing aggressive efforts for reducing deer density and for controlling interfering vegetation. These activities will need to be conducted within landscapes managed by silvicultural systems that produce mandated public outputs while enhancing the diversity of forest resources.

The current emphasis of the Forest Service to practice 'Ecosystems Management' reflects a desire to manage all forest resources in an ecologically sound manner. To achieve this end, the Forest Service and other agencies managing public and private forests need to cut through the confrontational rhetoric of such groups as deer hunters and environmental groups and provide them with clear examples (from research) of how factors affecting such forest values as diversity need to be and can be managed.

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