Impacts of White-Tailed Deer Overabundance in Forest Ecosystems: An Overview

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Introduction

The white-tailed deer (*Odocoileus virginianus*) occupies a prominent position in the fabric of the American experience. The past, present, and future importance of this magnificent animal is immeasurable.

Seeing a deer in the forest (or in the headlights) is no longer a rare event in much of the country (Figure 1). Despite record harvests in recent years, deer populations are at or near all-time highs in many States. Why have deer become so numerous? How are they affecting forest ecosystems? Why should landowners, forest managers, and the general public be concerned?

This document will address these questions and attempt to focus attention on the issue of white-tailed deer overabundance in the context of the forest resource.

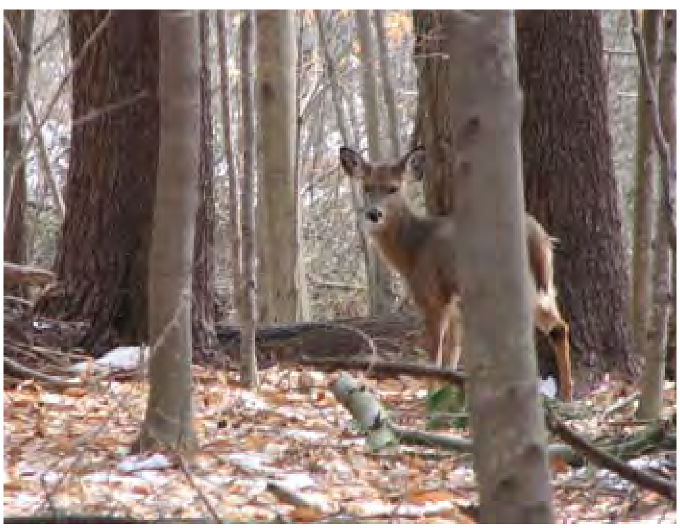

Figure 1.—White-tailed deer are frequently seen in this Massachusetts forest.

The Deer Population Explosion

White-tailed deer are adaptable and prolific animals equipped with keen survival instincts (Halls 1984). Major predators such as the gray wolf (*Canis lupus*) and cougar (*Puma concolor*) have been extirpated from much of the deer's range (Cote and others 2004; Rooney and Waller 2003). Because of human intervention, the range of the whitetail has actually expanded to include offshore islands, such as Block Island, RI, where seven deer introduced in 1967 grew to a herd of 700 deer by 1994 (Rhode Island Department of Environmental Management, Division of Fish and Wildlife 2007). In addition to the food sources available to them in forests, deer have successfully exploited the human-altered environment, feeding in agricultural fields, orchards, roadsides, lawns, and gardens.

State wildlife management agencies and hosts of cooperators have achieved broad successes in managing deer populations at ecologically and socially acceptable levels, primarily through regulated hunting (McDonald and others 2007; Winchcombe 1992). But in certain regions, deer populations remain higher than many people desire. In Wisconsin, for example, the 2005 post-hunt deer population was more than 50 percent above the goal established for 60 of the State's 120 deer management units (Rolley 2006). At high population densities, deer can reach nuisance levels, posing hazards to human health and safety, inflicting economic hardships, and degrading forest ecosystems (Drake and others 2005; Horsley and others 2003; Latham and others 2005; McShea and others 1997; Rooney 2001; Rooney and others 2004).

Latham and others (2005, p. 45) provide important insights into this complex issue:

> There is a widespread impulse to blame recent policies and management actions, or inaction, for the current deer situation, but the ultimate causes run much deeper and have been around for a very long time. Profound changes to the landscape and to interactions among wildlife species brought about by humans are responsible for the current high densities of white-tailed deer and their pervasive effects on the rest of the ecosystem.

These changes are persistent and difficult to reverse, which means that there is no quick fix. Any remedy for the deer problem will require persevering with carefully targeted efforts indefinitely.

Ecological Effects of Deer Overabundance

What's wrong with this picture (Figure 2)?

FIGURE 2.—This Suffolk County, NY, oak forest shows evidence of white-tailed deer overabundance.

The trees in this Long Island forest look healthy, and they probably are. But look closely. Saplings and shrubs are missing. They have succumbed to the effects of chronic deer browsing. Canada mayflower,[1] an otherwise common species, is now common only within the protective confines of a nearby fenced exclosure. Early sweet blueberry bushes inside the fence are bountiful, while those on the outside are heavily browsed and devoid of fruit. The forest floor is presently dominated by unpalatable plant species, such as black huckleberry, Japanese barberry, Pennsylvania sedge, and various woodland grasses. As trees mature and die, or topple over during storms, gaps in the canopy become larger and more numerous. There are no young trees to fill the gaps.

These same effects are repeated in many other forest types, including the sugar maple forest depicted in Figure 3. Deer have denuded this forest of its shrubs and saplings, jeopardizing future regeneration. Birds that nest in shrubs, or in the intermediate layers of the forest, have most likely declined (deCalesta 1994). The native white trilliums (Figure 4) that once dominated the forest floor have all but disappeared. The forest floor is presently dominated by garlic mustard, an invasive exotic that the deer avoid eating.

FIGURE 3.—A Cayuga County, NY, sugar maple forest shows a few surviving white trilliums in the foreground.

FIGURE 4.—White trillium, a native wildflower, can be decimated by deer (Rooney and Gross 2003).

White-tailed deer have been described as keystone species in forest ecosystems (McShea and Rappole 1992; Rooney 2001; Rooney and Waller 2003), implying that their feeding activity can directly and indirectly affect many other species. It has been said that deer are grazers by choice, browsers by necessity. During the spring and summer they feed primarily on herbaceous plants and the leaves of woody plants. In the fall, acorns and fallen fruits are favored. Browsing of woody stems is prevalent in winter, when other food sources are usually in short supply.

At high population densities deer can greatly alter the appearance and ecology of forest vegetation. Forest Service Ecologist Susan Stout made this poignant observation (U.S. Department of Agriculture, Forest Service 2004, p. 1):

[1] See appendix 1 for a complete list of all scientific and common plant names referenced in this document.

We think we know our forests. But in Pennsylvania and many other parts of the Northeast, deer overabundance has changed our forests so much and for so long that we truly don't know how our forests would look without too many deer. I walk inside a fence that's been up for three or four years in the springtime, and I am amazed at the wildflowers and seedlings I find.

The young oaks pictured in Figure 5 clearly illustrate Dr. Stout's point.

FIGURE 5.—Oak seedlings and young saplings thrive within an Orange County, NY, deer exclosure. (Photo by Matt Paul, New York Department of Environmental Conservation)

Having studied deer impacts for decades, Forest Service Researcher Stephen Horsley made this assessment (U.S. Department of Agriculture, Forest Service 2004, p. 4):

The current density is producing devastating and long-term effects on forests. Foraging deer "vacuum up" the seedlings of highly preferred species, reducing plant diversity and in the extreme, creating near mono-cultures. It could take decades or even hundreds of years to restore forests. . . . Deer have the capacity of changing forest ecology, by changing the direction of forest vegetation development. It doesn't matter what forest values you want to preserve or enhance—whether deer hunting, animal rights, timber, recreation, or ecological integrity—deer are having dramatic, negative effects on all the values everyone holds dear.

Foresters have long sought to mitigate detrimental impacts of overabundant deer. The Michigan Society of American Foresters recently issued a position statement on the subject, which begins (Michigan Society of American Foresters 2006, p. 1):

The Michigan Society of American Foresters advocates the sustainable use and management of all Michigan forest resources for the good of society. To do this, white-tailed deer (*Odocoileus virginianus*) populations must be low enough to allow for the regeneration of forests and the development of desired plant communities and wildlife habitats.

These same concerns were expressed in Wisconsin (Wisconsin Society of American Foresters 2007):

Deer herbivory in Wisconsin forests is causing economic and ecological losses by reducing tree survival and growth, and altering species and age composition. The continued overabundance of deer can directly threaten the future of sustainable forestry. Research in Pennsylvania has shown that future economic impacts are avoidable, and that detrimental ecological impacts to forest plant and animal communities are preventable but only if action is taken to reduce deer numbers. The opportunity to reduce the economic and ecological effects is within reach if deer numbers are reduced in a timely and strategic manner.

Regeneration failure caused by deer on 35,000 acres of industrial forest land in the upper Midwest is jeopardizing a company's compliance with environmental certification programs (Donovan 2005). To participate in the growing marketplace for certified, or "green," forest products, industrial and non-industrial forest managers alike must find and implement long-term solutions to their deer impact problems. The challenge can be daunting.

Botanists have decried the effects of deer overabundance. In a survey of professional botanists and natural resource managers, Miller and others (1992) found that 98 threatened or endangered plant species were damaged by deer. On Block Island, RI, a fence protects the globally rare New England blazing star (Enser 2002). In the central Appalachians, American ginseng populations are being devastated by deer. McGraw and Furedi (2005, p. 921) concluded that:

. . . current deer population densities in central Appalachia jeopardize the future of ginseng, as well as the culture of harvest and trade surrounding this important herb.

Former New York State Botanist Richard S. Mitchell described landscape-level impacts of deer in the Hudson Valley (Mitchell 1997, p. 3):

> After personally exploring hundreds of miles, seeking every habitat in Harriman State Park and surrounding areas, I can tell you first hand that the vegetation there has been devastated by deer. Nearly every green thing has been nipped, often to the ground. Orchids and other rare herbs have shown a steep decline since the 1940s, and serious forage damage is evident throughout, from dry ridge-tops to trampled wetlands.

Some plants resist deer herbivory, owing to chemical or morphological defenses or low digestible content (Cote and others 2004). Among tree species, black cherry would be classified as fairly resistant. Horsley and others (2003) demonstrated a trend toward black cherry dominance in forests impacted by deer. At Rock Creek Park in Washington, D.C., Rossell and others (2007) found all major woody species to be impacted by deer, with the exception of American beech and spicebush. At very high population densities deer will ultimately browse black cherry, American beech, spicebush, mountain laurel, and many other less palatable species.

Native herb populations are often decimated by deer, but some species are consistently avoided. Examples include white snakeroot, black bugbane, mayapple, blue cohosh, Pennsylvania sedge, and eastern hayscented fern. A forest understory dominated by deer-resistant species is usually diagnostic of a forest afflicted by overly abundant deer. Foresters are especially concerned that eastern hayscented fern has become too abundant in some areas, preventing or impeding tree seedling establishment (Horsley and others 2003).

Deer also feed on invasive exotic plant species and can suppress the growth of some of them (Rossell and others 2007). But in many cases, the invasives appear to be disproportionately resistant to deer herbivory. Examples include Japanese stilt grass, garlic mustard, dames's rocket, black swallow-wort, creeping buttercup, chervil, celandine, goutweed, glossy buckthorn, Japanese barberry, multiflora rose, jetbead, wine raspberry, and tree-of-heaven. It may be difficult to determine if these invasives achieve dominance by directly out-competing native plants, or by exploiting the niches left vacant by the decimated natives. Kalisz and others (2003) found that garlic mustard became more abundant in control plots (where deer were present), while native herbs became more abundant within fenced exclosures. Garlic mustard, in turn, produces antifungal chemicals that can suppress native plant growth by disrupting mutualistic associations between native tree seedlings and belowground mycorrhizal fungi (Stinson and others 2006). The possible connections between deer, garlic mustard, and soil fungi illustrate the profound complexity of forest ecosystems.

The study by Kalisz and others (2003) may herald a promising new frontier of invasive plant control in which native plants—allowed to flourish in the absence of excessive deer damage—are used to suppress the growth of invasive exotics. A New York State forester put it this way (Callan 2007):

> Native plants can beat invasives if given a level playing field.

White-tailed deer consume the seeds and fruits of many plant species, and when excreted, a surprisingly large number of seeds remain viable. In a Connecticut study, seedlings of 57 different plant species were germinated from deer pellets (Williams and Ward 2006). Of these, 32 species were exotic. Among the exotics were some highly invasive species, such as autumn olive, wine raspberry, and multiflora rose. The authors made the following point in their discussion (Williams and Ward 2006, p. 389):

> White-tailed deer are one mechanism for transportation of exotic species into, and establishment in, depauperated habitats created by overbrowsing. Limiting the size and growth of white-tailed deer populations near the suburban/woodland interface would help prevent, or at least reduce, the further spread of undesirable exotic plant species and help maintain viable native plant populations.

Williams and Ward (2006) provide some evidence implicating deer in the spread of exotic plant species in forests, but much remains to be learned about deer-plant interactions. A forested landscape will contain hundreds of native and scores of exotic plant species. Within such a landscape, deer impacts will vary spatially, temporally, and among plant species, in relation to the population density of the deer herd. The ecological impacts of deer are complex and varied, but all too often it is clear that these impacts are detrimental to forest health and sustainability.

Working Toward Solutions

Landowners are encouraged to monitor deer impacts and, when necessary, to seek guidance from natural resource professionals who may be able to suggest remedial measures such as hunting, culling, fencing, repellents, scare devices, vegetation management options, or integrated combinations of these (Figure 6). Such measures may not eliminate deer damage, but reduce it to tolerable levels. Many sources of helpful information exist (e.g., Curtis and Sullivan 2001; Decker and others 2004; Ebersole 2006; Latham and others 2005; Pierce II and Wiggers 1997), but the problem remains large. Different regions and different sites within the same regions may face very different sets of challenging circumstances.

FIGURE 6.—Hunting remains an important tool in the management of white-tailed deer populations.

Landowners, municipalities, natural resource agencies, and other stakeholders are increasingly coming together to seek community-based solutions to their deer impact problems. Riley and others (2003) find hope in this approach:

> No easy solutions exist, although several conclusions are apparent from our experience in New York. We believe a paradigm shift, already underway in some states, is needed in public white-tailed deer management. The shift needed is from one of protection and distribution of a scarce resource to one of managing impacts of deer. More focus on education and engagement of non-hunting stakeholders is needed to ensure that decisions about hunting and population control arise from community deliberation and not merely from agencies. To be effective, any population-control mechanism will require acceptance by society.

There is no "quick fix" to this problem, but through greater awareness, cooperation, and perseverance, successes can be achieved.

The Forest Service recognizes that white-tailed deer overabundance has become a serious forest health issue, especially in the 20 Northeastern and Midwestern States (U.S. Department of Agriculture, Forest Service 2003, p. 32). These States contain 23 percent of the Nation's forests, 93 percent of which are non-federally owned. In this region and elsewhere the Forest Service will continue to promote well-managed forests to provide sustainable benefits and environmental services for the American public.

In conclusion, we reflect on the eloquence of Aldo Leopold who wrote in 1944 (Meine 1988, p. 465):

> Conservation is a state of health in the land. The land consists of soil, water, plants, and animals, but health is more than a sufficiency of these components. It is a state of vigorous self-renewal in each of them, and in all collectively. Such collective functioning of interdependent parts for the maintenance of the whole is characteristic of an organism. In this sense, land is an organism, and conservation deals with its functional integrity, or health.

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Appendix 1. Plant names used in the text, arranged taxonomically.

Family and Scientific Name	Common Name	Native (N) or Introduced (I)
Aceraceae (Maple Family)		
Acer saccharum	sugar maple	N
Apiaceae (Parsley Family)		
Aegopodium podagraria	goutweed	I
Anthriscus sylvestris	chervil	I
Araliaceae (Ginseng Family)		
Panax quinquefolius	American ginseng	N
Asclepiadaceae (Milkweed Family)		
Cynanchum louiseae	black swallow-wort	I
Asteraceae (Aster Family)		
Ageratina altissima	white snakeroot	N
Liatris scariosa var. *novae-angliae*	New England blazing-star	N
Berberidaceae (Barberry Family)		
Berberis thunbergii	Japanese barberry	I
Caulophyllum thalictroides	blue cohosh	N
Podophyllum peltatum	mayapple	N
Brassicaceae (Mustard Family)		
Alliaria petiolata	garlic mustard	I
Hesperis matronalis	dame's rocket	I
Elaeagnaceae (Oleaster Family)		
Elaeagnus umbellata	autumn olive	I
Ericaceae (Heath Family)		
Gaylussacia baccata	black huckleberry	N
Kalmia latifolia	mountain laurel	N
Vaccinium pallidum	early sweet blueberry	N
Fagaceae (Beech Family)		
Fagus grandifolia	American beech	N
Lauraceae (Laurel Family)		
Lindera benzoin	spicebush	N
Papaveraceae (Poppy Family)		
Chelidonium majus	celandine	I
Ranunculaceae (Buttercup Family)		
Actaea racemosa	black bugbane	N
Ranunculus repens	creeping buttercup	I
Rhamnaceae (Buckthorn Family)		
Frangula alnus	glossy buckthorn	I
Rosaceae (Rose Family)		
Prunus serotina	black cherry	N
Rhodotypos scandens	jetbead	I
Rosa multiflora	multiflora rose	I
Rubus phoenicolasius	wine raspberry	I
Simaroubaceae (Quassia Family)		
Ailanthus altissima	tree-of-heaven	I
Cyperaceae (Sedge Family)		
Carex pensylvanica	Pennsylvania sedge	N
Liliaceae (Lily Family)		
Maianthemum canadense	Canada mayflower	N
Trillium grandiflorum	white trillium	N
Poaceae (Grass Family)		
Microstegium vimineum	Japanese stilt grass	I
Dennstaedtiaceae (Bracken Family)		
Dennstaedtia punctilobula	eastern hayscented fern	N