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Introduction

The scientific evidence is clear. White-tailed deer overabundance is a threat to millions of acres of forest land in the Northeastern United States.[1] As keystone herbivores, whitetails can have disproportionately large impacts on biodiversity and forest dynamics. Impacts may be obvious or may cascade through the ecosystem in ways not fully understood.

Human actions and inaction are the root cause of this problem.[2] Consider the implications of this statement:[3]

"Unfortunately, fewer than half of Pennsylvania's forest holds adequate numbers of young trees to simply replace itself."

Without young trees coming on, deer-impacted forests face a bleak future. These forests have lost much of their capacity to withstand disturbance and to absorb change. The natural disturbances that once diversified and rejuvenated forested landscapes now simply accelerate forest disintegration (figures 1, 2). Forest management is no longer sustainable in many areas (figure 3). Few, if any, threat factors can inflict such damage to forest ecosystems and forest-related economies.

Secondary succession describes the sequential development of vegetation, beginning quite often with abandoned agricultural lands and progressing to meadow, scrub, and then forest. But now, because of deer, many forests are disintegrating. Trees that die or topple over are not being replaced. Meadow grasses are becoming re-established in the canopy gaps.

Ecologists have a term for this phenomenon— retrogressive succession. The term describes temporal changes in ecological communities that lead to simpler states of those communities, with less biomass, diminished structural complexity, and fewer species over time. These communities are regressing to depauperate versions of their earlier stages of succession, driven by the destructive effects of white-tailed deer.

A clear imperative exists to document and understand deer impacts. Information of this kind, gathered by professional and citizen scientists alike, can help landowners, policymakers, and land managers make informed decisions about deer management.

Public participation in the information gathering and decisionmaking processes can only foster broader acceptance of deer management programs.

Forest habitat degradation by white-tailed deer is not a new problem. Durward L. Allen wrote about it in his book, *Our Wildlife Legacy*, originally published in 1954:[4]

> *"The beginning of range deterioration usually is evident only to the specialist. It involves gradual reduction of the most palatable woody plants and their replacement with species that deer do not like. An insidious destruction of habitat takes place while people delay and bicker."*

Figure 1. Fire has hastened the disintegration of this deer-damaged forest. Harriman State Park, NY.

Figure 2. An advanced stage of forest disintegration caused by deer and accelerated by fire. Blue Hills Reservation, MA.

[1] U.S. Department of Agriculture, Forest Service. 2013. Northeastern Area State and Private Forestry Strategic Plan Fiscal Years 2013-2018. NA-IN-01-13. Newtown Square, PA: Northeastern Area State and Private Forestry. 27 p.

[2] Latham, Roger E.; Beyea, Jan; Benner, Merlin; Dunn, Cindy Adams; Fajvan, Mary Ann; Freed, Ronald R.; Grund, Marrett; Horsley, Stephen B.; Rhodes, Ann Fowler; Shissler, Bryon P. 2005. Managing white-tailed deer in forest habitat from an ecosystem perspective: Pennsylvania case study. Report by the Deer Management Forum for Audubon Pennsylvania and Pennsylvania Habitat Alliance, Harrisburg, PA. xix + 340 p.

[3] Pennsylvania Department of Conservation and Natural Resources. [n.d.]. Healthy forests—healthy deer: finding the right balance. Brochure. Pennsylvania Department of Conservation and Natural Resources.

[4] Allen, Durward L. 1954. Our wildlife legacy. New York: Funk and Wagnalls: 139.

White-tailed deer and forests can coexist in a healthy balance. In fact, most forests in the Northeast are in such a balance. What defines a healthy balance? The Pennsylvania Department of Conservation and Natural Resources offered this guidance:[3]

"It's all about reading the forest. When we find a wide variety and abundance of young trees, shrubs, and wildflowers—a healthy understory—and the forest exhibits the ability to replace itself, then we know we are close to finding that critical balance between deer and the forest."

This document provides additional guidance on reconnaissance-level assessment of deer impacts. The focus is on the plant life. Most examples are drawn from New England and New York. This is not an exhaustive literature review, though ample evidence certainly exists in the scientific literature to bolster much of this. It is, instead, an illustrated compendium of the author's observations and helpful hints, with some reference to published findings. Yes, it is ultimately about reading the forest—observing and perceiving.

Figure 3. Installation of deer fencing to protect developing forest vegetation. Scituate, RI.

The White-tailed Deer

The white-tailed deer is a wide-ranging, prolific, and adaptable prey species endowed with acute senses and keen survival instincts (figure 4). The U.S. deer population has skyrocketed in recent decades to reach an estimated 30 million animals.[5]

Understanding the ecology of the white-tailed deer requires time spent reading the literature and time spent in the woods, observing not only the plant life but also the habits of these animals. Whitetails are generalist herbivores. They feed on a wide variety of plant species and plant parts. They also eat mushrooms, lichens, and sometimes even seaweed.

They can be very selective in their dining preferences, especially during spring and summer when forage is plentiful (figure 5). Their diet changes seasonally. In winter they become less selective, browsing twigs, eating the leaves of less-palatable evergreen plants, and venturing more boldly into neighborhoods to feed on lawns and landscaping. Humans sometimes feed wild deer, either intentionally or unintentionally.

To reiterate, white-tailed deer are herbivores—they must eat plants. We all want deer in our forests and have to accept some level of browse damage to the plant life. It's all part of Nature's design.

Concerns arise when deer, at high population densities, deplete palatable forage and resort to desperate measures. They will strip and eat bark from witch hazel and hemlock and dig into the ground—like wild hogs—in search of Indian cucumber-

Figure 4. A doe and fawn. North Smithfield, RI.

Figure 5. A white-tailed deer feeding in a forest. Lenox, MA.

[5] Rooney, Thomas P. 2010. What do we do with too many white-tailed deer? Action Bioscience. http://actionbioscience.org/biodiversity/rooney.html. (10 November 2014).

roots (figure 6). They can degrade nearly every square foot of understory vegetation (figure 7). Suffering the consequences of their own overbrowsing, whitetails become undernourished, undersized, and more susceptible to winter die-off.

Skittish and secretive by day, whitetails become emboldened and active at night. How does one come to understand these elusive and largely nocturnal animals?

Here's one way. Visit a forest after a fresh snowfall. The deer tracks will give a sense of the number of animals using the area. You may find the tracks of a lone buck, a doe with a fawn, or the tracks of a small herd of deer. Then, start following a set of tracks backwards, so as not to disturb the animals. You will gain remarkable insights about their travels and feeding habits (figure 8).

In many suburban environments whitetails have become habituated to the presence of humans. You may observe fascinating behaviors at close range in those settings (figure 9).

Hunters know whitetails better than most. The most successful hunters scout their lands well in advance of the hunting season. It is, after all, in the hunter's interest to learn as much as possible about his or her quarry. "Find the food, find the deer" is an axiom of deer hunting. Trail cameras have become very popular, providing information about individual deer and their movement patterns.

Figure 6. Using its lower incisors, a deer stripped and ate the bark of this witch hazel. Scituate, RI.

At some density, deer begin to have serious negative impacts on forest vegetation. That threshold density was determined to be >8 deer per square kilometer (or >20 deer per square mile) from a study conducted in Pennsylvania.[6] While that threshold density has been widely accepted, some believe that a lower threshold density exists in the Adirondacks, and that a higher threshold exists in agricultural districts, where deer have supplemental sources of forage.

There is a moot aspect to this topic because deer density is so difficult to determine with any high degree of accuracy. It is, ultimately, the condition of the understory that reveals much about deer density relative to the habitat's carrying capacity.

[6] Horsley, Stephen B.; Stout, Susan L.; deCalesta, David S. 2003. White-tailed deer impact on the vegetation dynamics of a northern hardwood forest. Ecological Applications. 13(1): 98–118.

Figure 7. Tracks show how thoroughly deer traverse the forested landscape. Scituate, RI.

Figure 8. A deer poked its nose into the snow (lower impressions) while feeding on the polypore mushrooms growing on this log. Stow, MA.

Figure 9. In many suburban areas, deer have become part of our environment and we theirs. Dutchess County, NY.

Figure 10. Fenced arborvitaes shaped into bizarre forms by deer browsing. Schoharie County, NY.

Figure 11. Browse damage to arborvitaes. The deer evidently walked up the patio steps. Westford, MA.

Wildlife management agencies have good information on statewide deer densities. On maps that partition States into wildlife management units, those units are often described as being *at*, *below*, or *above* deer management goals. Although deer management goals incorporate considerations of both habitat and cultural carrying capacity, as a general rule wildlife management units that are *at* or *below* deer management goals will have healthy forests from a deer impact perspective. Most of northern New England would fall into these low-impact categories.

Forest Vegetation

Before ever stepping into a forest, pay attention to deer impacts in the neighborhood. Do ornamental shrubs show browse damage (figures 10, 11)? Are gardens surrounded by tall fences (figure 12)? Do browse lines exist along forest edges? Such observations will give a sense of what to expect in the forests.

Upon entering a forest, watch for deer sign—tracks, trails, fecal pellet groups, buck rubs, and buck scrapes (figures 13, 14). The amount of deer sign will give a rough indication of the amount of browse damage to be expected.

Try to make multiple visits to forests of interest. Each season will bring new insights.

To name is to know. Hone your skills at identifying plant species. In itself, this is an enjoyable and rewarding activity. In the context of understanding deer impacts, it is an essential prerequisite. Take advantage of opportunities to accompany experienced naturalists into the woods. Take notes, photographs, and specimens as permissible. Popular field guides to trees, shrubs, and wildflowers should be at the ready. With practice, one will be able to identify these plants even when they lack the pretty flowers shown in the field guides, as they will so often appear when browsed by deer.

Rely on senses in addition to sight when trying to identify a plant. Distinguish a forest goldenrod from an aster by the crushed leaf fragrance of the former. Learn the pungent fragrance of peeled black cherry bark. The terminal bud of sugar maple is pointy and sharp, whereas the terminal bud of red maple is altogether harmless in this regard.

Figure 12. Fencing protects ornamental shrubs from deer damage. Southold, NY. (Photo by John Rasweiler IV)

Figure 15. A biologist measures a deer-browsed spicebush on the edge of a wetland. Seneca County, NY.

Figure 13. Deer droppings, also referred to as a pellet group. Braintree, MA.

Figure 16. A healthy sugar maple forest, showing complex structure. Buckland, MA.

Figure 14. A buck rub on a sapling. Sudbury, MA.

Figure 17. Simple structure of a deer-impacted sugar maple forest. Dutchess County, NY.

Figure 18. Simple structure of a deer-impacted oak forest. Hampshire County, MA.

Figure 19. Simple structure and a recalcitrant understory of hay-scented fern. Scituate, RI.

Figure 20. A browse line, as viewed from an opening. The entire forest is likely negatively impacted by deer. Dutchess County, NY.

Figure 21. A browse line on the lower branches of American beech. West Greenwich, RI.

Figure 22. A browse line on the lower branches of small hemlock trees. Stow, MA.

Figure 23. Deer browsing created these "lollipop" hemlocks. Sherborn, MA.

Figure 24. Sprouts at the base of this red maple stump are not able to grow above the reach of deer. Scituate, RI.

Figure 25. Sprouts at the base of this beaver-cut tree are not able to grow above the reach of deer. Harvard, MA.

Figure 26. Fields often stay as fields where deer are abundant. Shelter Island, NY. Note the browse line on the eastern red-cedar.

Notice how the forest vegetation changes along environmental gradients. Different plant communities will be found along those gradients, with different suites of plant species to be examined. Don't forget to examine the wetlands because they are often heavily utilized by deer (figure 15).

Observe the structure of the vegetation. Healthy forests will have complex structure with well-developed herb, shrub, sapling, and tree layers (figure 16). Forests influenced by too many deer will develop simple structure characterized by sparse shrub and sapling layers. Walking tends to be easy in forests with simple structure, and you can see a long way through the woods (figures 17, 18). With simple vegetation structure, more sunlight reaches the forest floor, allowing browse-resistant plants such as hay-scented fern to thrive (figure 19). Such areas are now referred to as fern savannas or fern parks instead of forests.

Browse lines are often diagnostic of high deer impact (figure 20). Browse lines tend to occur on the edges of a forest, as viewed from an opening. Mountain laurel, great laurel, and American beech can show browse lines in forest interiors (figure 21). Eastern hemlock can also show a browse line and "lollipop" saplings (figures 22, 23). If the branches of young hemlock trees (growing singly in the forest) practically touch the ground, the deer impact is inconsequential. If no hemlock branches grow lower than 6 feet, there might be cause for concern. If white pine or American holly saplings show a browse line, the deer impact is very high!

In logged areas, examine tree stumps for sprout growth. If some of the sprouts are able to grow above the reach of deer, withstanding some inevitable browse damage along the way, the deer impact is usually tolerable. If, on the other hand, the deer are preventing this, and the regeneration of the forest is being compromised, the deer are interfering with forest management objectives (figure 24). In the absence of logging activity, search out beaver ponds. Examine the older beaver-cut stumps. Were the sprouts able to grow above the reach of the deer (figure 25)?

Deer impacts are often more pronounced on islands, owing perhaps to the emigration barrier and a paucity of wild predators. But deer can swim considerable distances or move between islands and the mainland when lakes are frozen.

Because of deer, the natural succession of field to forest can be slowed or almost halted. Where deer exist in high densities, fields often stay as fields, for decades, albeit with some colonization of browse-resistant shrubs such as bayberry (figure 26). Trees that attempt to colonize the fields are mostly browsed to death or kept suppressed.

Of Moose and Rabbits

Where deer and moose coexist, browse damage from the two can sometimes be indistinguishable. Deer and moose both lack upper incisors. When they browse a twig, a frayed bit of bark is often left at the end (figure 27). Any browse damage found above 6 feet high can be attributed to moose, though deer will sometimes stand on their hind legs to reach above this height to browse things that they really want. Moose tend to browse larger diameter twigs. Tracks and fecal pellets in the vicinity can often implicate the deer's larger cousin.

Where deer and rabbits (or hares) coexist, deer browse damage can be distinguished by the frayed end of the browsed twig. Rabbits and hares have upper and lower incisors. The twigs they cut are neatly severed and angled, without a frayed end. Twigs and small branches cut by rabbits are often brought to the ground and then eaten in their entirety (figure 28).

Figure 27. Moose browse damage to large-diameter red maple stems. Note the frayed end, typical of both deer and moose browse damage. Rutland, MA.

Figure 28. An eastern cottontail will snip off a twig, bring it to the ground, and eat the whole thing. Oakham, MA.

Fenced Areas and Other Inaccessible Places

Fenced land and places inaccessible to deer can provide important insights. There may be deer exclosures to be examined or other areas that function as de facto exclosures (figures 29, 30). Great places to examine include fences alongside interstate highways or surrounding stormwater retention basins and other restricted areas (figures 31, 32).

Fences are sometimes established specifically for protecting endangered plant species from deer damage (figures 33, 34). Those fences protect not only the rare plants but other fenced plants as well.

Deer are surprisingly adept at reaching vegetation growing on steep slopes, but they are not mountain goats. They cannot scamper up ledges or negotiate boulder-strewn areas. In such places, the vegetation will be fully developed, often with plant species that are absent, scarce, or undersized in the surrounding terrain. Much can be learned from these refugia (figures 35, 36).

Figure 29. Lush understory inside a deer exclosure. Scituate, RI. Yes, deer love poison ivy!

Figure 30. Deer have denuded the understory vegetation outside of this small exclosure. Kittery, ME.

Figure 33. Fencing protects the state-endangered sweet-bay magnolia from deer damage. Gloucester, MA.

Figure 31. Red maple saplings have grown tall within this fenced stormwater retention basin. Andover, MA.

Figure 34. New England blazing-star, a globally rare plant species, is protected by fencing on Block Island, RI.

Fgure 32. Pink dogbane, pink lady's slipper, and bristly sarsaparilla grow to full stature only within this fire tower fence. Scituate, RI.

Some plants that would otherwise be vulnerable to browse damage are afforded protection by their association with thorny shrubs. Perfoliate bellwort, for example, grows to full stature only beneath Japanese barberry bushes in a well-studied New York forest. Check to see what other plants may be thriving only in the thorny thickets.

Upper branches of fallen trees can create a barrier to deer movement, at least for a period of several years. Compare the vegetation amid the branches with that in adjacent areas (figures 37, 38). Foresters sometimes use the slash and tops of harvested trees to restrict a deer's access to young growth that develops after logging. Other such silvicultural practices may involve control of competing vegetation, exclusion fencing, or timber harvests large enough to overwhelm deer with regenerating forage.

Figure 35. Wild sarsaparilla, a preferred species, thrives only on this inaccessible ledge. Dutchess County, NY.

Figure 37. A small black gum sapling, protected from deer browsing beneath the crown of a toppled tree. Southold, NY.

Figure 36. Spring ephemerals grow in profusion at the base of a steep gorge where deer are absent. Fillmore Glen State Park, Cayuga County, NY.

Figure 38. Pokeweed and other plants are protected from deer by the branches of this fallen tree. Blue Hills Reservation, MA.

Deer Impacts are Never Uniform

Here one has to imagine the world from the deer's perspective. These animals are on the landscape 24/7/365 and learn it well. The minimum home range for a whitetail is about 200 acres and the maximum can approach 1,000 acres. Deer have favorite bedding, feeding, and probably also fawning areas. They use a network of trails through the forest that we humans can hardly comprehend.

Deer often find the best forage on the most fertile soils. Fertile soils, in turn, often reflect underlying geology and slope position. Consider the quartz conglomerate that caps the Shawangunk Ridge in New York. Soils there are very poor, supporting low-quality forage comprised of pitch pine, black huckleberry, mountain laurel, and wintergreen (figure 39). Underlying the conglomerate is shale, which is exposed along the slope of the ridge. The shale soils are more fertile and support a profusion of palatable forage. Deer impacts are more pronounced in forests growing on shale.

Early successional habitats, including forest edges and regenerating forests, provide abundant food for deer, especially winter browse. But when the acorns and beechnuts start dropping, the deer adjust their feeding patterns to exploit that sudden bounty (figure 40).

Facing deep snow conditions, whitetails may migrate many miles to coniferous swamps or other sheltered evergreen forests, which intercept snow and afford thermal protection.[7] Large numbers of deer may concentrate in these deer yards, causing extensive localized browse damage (figure 41). As winter loosens its icy grip, the deer visit south-facing slopes, where the snow melts first (figure 42).

Deer avoid frightening features of their environment. One rarely sees deer impacts of any consequence near busy roads, near trailheads, or in forests through which high school students run their cross country races (figure 43). Sometimes there are gradients in the intensity of herbivory, as reflected by the vegetation. Browse damage may be absent near the frightening features and becomes ever more pronounced with distance away from those features. These gradients are referred to as herbivoclines and they are absolutely fascinating.

There are some plant communities so thick with tangled growth that even the deer do not penetrate them. I explored one such area, a shrub-dominated wetland on Long Island. Crawling much of the way on wet sphagnum moss, through gaps in the bushes and briers, I found no deer sign whatsoever. For my troubles, I was rewarded by finding pink lady's slipper, an orchid long gone from the adjacent deer-impacted uplands (figure 44).

And so, for these many reasons, deer impacts are never uniform across the landscape. Patterns of variation exist.

[7] Halls, Lowell K., ed. 1984. White-tailed deer ecology and management. A Wildlife Management Institute book. Harrisburg, PA: Stackpole Books. 864 p.

Figure 39. Deer impact is negligible in pitch pine vegetation at the crest of the Shawangunk Ridge. Ulster County, NY.

Figure 40. Acorns produced by mature oaks form an important component of the deer's diet. Cayuga County, NY.

Figure 41. During the deep-snow year of 2011, this Atlantic white-cedar swamp served as a deer yard. Braintree, MA.

Figure 42. In early spring, acorns and other forage become available to deer on warm south slopes. Braintree, MA.

Figure 43. Deer avoid frightening features of their environment. Holden, MA.

Figure 44. Pink lady's slipper, a beloved wildflower that can be decimated by overabundant white-tailed deer. Scituate, RI.

Here Today, Gone Tomorrow?

It is difficult to say with certainty that deer were responsible for wiping out a plant species. With enough looking, these plants can often be found in little out-of-the-way places or as tiny browse-suppressed individuals. Or, these plants may be persisting in the soil seed bank, awaiting suitable conditions for germination. The larger point is that browse-impacted plants lose much of their functional role in ecosystems. They may not be able to produce flowers that would otherwise nourish native pollinators or the fruits that would otherwise be available for wildlife (figure 45).

American chestnut is one species that is steadily being wiped out from deer-ravaged landscapes. We all know about the chestnut blight. Chestnut persists today largely because of its sprouting abilities. But when those sprouts are heavily browsed and can no longer grow above the reach of deer, the tree root stock is weakened and succumbs. Deer browsing represents the final nail in the coffin for American chestnut in these areas (figure 46).

Figure 45. A deer-browsed lowbush blueberry that is too small to have much of a functional role in the ecosystem. Southold, NY.

Figure 46. An American chestnut tree, top-killed by the blight, will soon die because its sprouts can no longer escape deer damage. Scituate, RI.

The Element of Time

A Massachusetts forest has maple-leaf viburnum stems averaging 18 inches tall. A Pennsylvania forest has viburnum stems averaging 5 inches tall. Which forest has the higher deer density? This question cannot be answered with certainty. The two forests may have the same deer density. The element of time has to be considered. In Massachusetts, the deer density increased only in recent decades while in Pennsylvania that increase occurred many decades ago. It takes time—many years—for the deer to whittle away at woody plants, snipping off buds and causing the plants to become shorter and shorter until the last bud is snipped and the plant is top-killed. When top-killed, the plants send up short basal sprouts, as perhaps seen in the Pennsylvania forest.

Closely monitor woody plant height. Are the plants getting shorter or are they growing taller, perhaps in response to a deer management program?

A multitude of tree saplings can sometimes belie a serious deer impact problem. These tend to be larger saplings that began growth two or three decades ago, before deer herds grew to current high levels. Think of these as artifacts from the years when deer herds were smaller.

Hemlock saplings can sometimes indicate that a local deer herd has grown larger. Young hemlocks in Stow, MA, were able to grow 5 feet tall, largely unaffected by browse damage. But in recent years they have been browsed to death, suggesting that the deer herd has grown larger (figure 47).

Figure 47. Hemlock saplings browsed to death in recent years. Note the browse line developing on the larger saplings. Stow, MA.

Some impacts of white-tailed deer can linger in forests for many decades, irrespective of any changes occurring in deer density. Consider hay-scented fern. Its monocultures have been described as recalcitrant—stubborn and difficult to manage. Interlocking fronds and a thick rhizome mat all but preclude the establishment of other plants. The legacy effect of too many deer on a landscape can last a very long time.

Classes of Palatability

Classification, in its purest sense, is an organized form of cataloging based on fixed principles. There is utility in trying to assign plants to different classes of palatability. Some species are consistently browsed while others are consistently avoided. A forest understory lacking many of the preferred plants that would otherwise be there suggests significant deer impact, as does browse damage to the less-preferred plant species. Aldo Leopold wrote about this in 1933 in his book, *Game Management*: [8]

> *"Experience teaches us that the diet of game animals, through the critical winter season, often follows a more or less definite sequence. As one group of foods becomes exhausted or unavailable, a second group is taken, and as the second becomes exhausted, a third is taken. These groups presumably represent a descending order of palatability…."*

Leopold classified foods eaten as 1) preferred foods, 2) staple foods, 3) emergency foods, and 4) stuffing, this last category being reserved for material of no or little nutritive value. In 1941, George A. Petrides assigned woody plants of the Connecticut Hill State Game Refuge in New York to Leopold's palatability classes for deer. [9] In the preferred category, Petrides placed round-leaved dogwood, staghorn sumac, flowering dogwood, basswood, apple, and hobblebush. In the stuffing category, he placed blueberry, bush honeysuckle, sweet fern, and meadowsweet. Petrides concluded, based on the continued availability of the preferred plants and the lack of significant browse damage to the emergency and stuffing plants, that the game refuge was not being over-browsed by deer.

This same general approach can work today. However, assigning a plant to a palatability class can be somewhat arbitrary. The principles forming the basis of this classification are hardly fixed.

[8] Leopold, Aldo. 1933. Game management. New York: Charles Scribner's Sons: 258–259.

[9] Petrides, George A. 1941. Observations on the relative importance of winter deer browse species in central New York. Journal of Wildlife Management. 5(4): 416–422.

Preferred and Staple Plant Species

Under this category would fall apples, agricultural crops, lawn grass, and suburban landscaping. In forests, there are hundreds of preferred and staple food plants. Some of these, selected by the author, are listed in table 1 and discussed on the following pages.

Table 1. Some preferred and staple food plants for white-tailed deer in Northeastern forests.

Trees

Acer rubrum	Red Maple
Acer saccharum	Sugar Maple
Benthamidia florida	Flowering Dogwood
Chamaecyparis thyoides	Atlantic White-cedar
Fraxinus americana	White Ash
Juniperus virginiana	Eastern Red-cedar
Magnolia acuminata	Cucumber Tree
Magnolia virginiana	Sweet Bay
Nyssa sylvatica	Black Gum
Populus spp.	Aspen
Prunus serotina	Black Cherry
Quercus spp.	Oak
Thuja occidentalis	Arborvitae
Tilia americana	American Basswood
Tsuga canadensis	Eastern Hemlock

Shrubs/Vines

Amelanchier spp.	Shadbush
Clethra alnifolia	Sweet Pepperbush
Corylus cornuta	Beaked Hazelnut
Elaeagnus umbellata	Autumn Olive
Euonymus alata	Winged Euonymus
Hamamelis virginiana	Witch Hazel
Ilex montana	Mountain Winterberry
Ilex verticillata	Winterberry
Ligustrum spp.	Privet
Lindera benzoin	Spicebush
Lonicera japonica	Japanese Honeysuckle
Lonicera morrowii	Morrow's Honeysuckle
Malus spp.	Apple
Parthenocissus quinquefolia	Virginia Creeper
Prunus virginiana	Choke Cherry
Quercus ilicifolia	Scrub Oak
Rhamnus cathartica	Common Buckthorn
Rhododendron periclymenoides	Pinxter-flower
Rhus spp.	Sumac
Rosa multiflora	Multiflora Rose
Rubus spp.	Blackberry/Raspberry
Salix cinerea ssp. oleifolia	Rusty Willow
Sambucus racemosa	Red Elderberry
Smilax rotundifolia	Common Greenbrier
Staphylea trifolia	Bladdernut
Swida alternifolia	Alternate-leaved Dogwood
Swida spp.	Dogwoods
Taxus canadensis	Canada Yew
Taxus cuspitata	Japanese Yew
Toxicodendron radicans	Poison Ivy
Viburnum acerifolium	Maple-leaf Viburnum
Viburnum lantanoides	Hobble-bush
Vitis spp.	Grape

Herbaceous Plants

Aralia nudicaulis	Wild Sarsaparilla
Chamaepericlymenum canadense	Bunchberry
Chelone glabra	Turtle-head
Clintonia borealis	Bluebead Lily
Cypripedium acaule	Pink Lady's Slipper
Cypripedium parviflorum	Yellow Lady's Slipper
Erythronium americanum	Trout Lily
Eurybia divaricata	White Wood-aster
Eurybia macrophylla	Large-leaved Wood-aster
Impatiens capensis	Spotted Touch-me-not
Liatris borealis	New England Blazing-star
Lilium canadense	Canada Lily
Lythrum salicaria	Purple Loosestrife
Maianthemum canadense	Canada Mayflower
Maianthemum racemosum	False Solomon's Seal
Medeola virginiana	Indian Cucumber-root
Nabalus serpentarius	Lion's-foot Rattlesnake-root
Panax quinquefolius	American Ginseng
Phytolacca americana	Pokeweed
Polygonatum biflorum	Solomon's Seal
Pteridium aquilinum	Bracken Fern
Solidago caesia	Bluestem Goldenrod
Streptopus lanceolatus	Twistedstalk
Symphyotrichum lateriflorum	Calico Aster
Trillium grandiflorum	White Trillium
Uvularia perfoliata	Perfoliate Bellwort

Trees

Deer will eat the leaves, young branches, and fruit of many tree species. The tender foliage that appears soon after bud burst is especially attractive to them. Leaves of oak, red maple, sugar maple, white ash, cucumber tree, and American basswood are especially preferred. Later in the summer, when tree leaves have hardened, the deer are less attracted to them.

Sugar maple is the most common and arguably the most important tree species in New York State. As a food source for deer, it is widely available and preferred. Deer impact is tolerable if at least some of the sugar maple saplings are able to grow tall enough to escape deer damage (figure 48).

Flowering dogwood is a preferred species that is facing double trouble. Anthracnose is killing the taller stems and deer are browsing the shorter ones (figure 49).

Aspens are somewhat preferred. Their fast-growing root sprouts can sometimes grow above the reach of deer in just one year.

Black cherry may be somewhat less preferred than other tree species, but its saplings are readily browsed and can be suppressed by deer.

Evergreen trees such as eastern hemlock, northern white-cedar (arborvitae), eastern red-cedar, and Atlantic white-cedar aren't as preferred in summer as they are in winter when other forage is in short supply (figure 50).

Shrubs/Vines

Canada yew is a highly preferred evergreen shrub. It can be negatively impacted even when deer densities are quite low. Similarly, at low densities, deer can negatively impact hobblebush, red elderberry, and alternate-leaved dogwood (figure 51). The term "deer candy" might be applied to these shrubs. Shadbush, blackberry, raspberry, sumac, choke cherry, dogwoods, and all viburnum species are preferred, as is the young growth of common greenbrier (figure 52). Scrub oak is preferred, but its dense growth often limits browse damage to the periphery of these plants.

Some non-native shrubs are preferred, namely common buckthorn, privet, Japanese honeysuckle, Japanese yew, rusty willow, and winged euonymus (figure 53). Multiflora rose is relished by deer when the plants are young, but with age, the plants develop the thorny armature that deters browsing. Similarly, deer will readily browse Morrow's honeysuckle and autumn olive when the plants are small, but the dense growth that develops with age tends to deter browsing.

Figure 48. A sea of little sugar maple saplings. None are able to grow tall enough to escape deer damage. Chenango County, NY.

Figure 49. A browsed sprout of flowering dogwood, a preferred species. Shelter Island, NY.

Figure 50. Bent by the weight of heavy wet snow, these Atlantic white-cedar saplings were stripped bare by deer. Braintree, MA.

Figure 51. Hobblebush is preferred by deer and moose alike. Gloucester, MA. In many areas, no hobblebush plants are able to grow tall enough to produce flowers.

Examine the small stems at the base of witch hazel, winterberry, mountain winterberry, pinxter-flower, and spicebush. As the larger stems grow old, the smaller ones are poised to take their place. But deer can prevent the small stems from growing very tall, thus placing in jeopardy the continued survival of these shrubs (figures 54, 55). Sweet pepperbush, beaked hazelnut, and gray dogwood grow as expanding clones. The smaller stems emerging along the periphery of the clones can be especially vulnerable to browse damage.

Virginia creeper and poison ivy are both widely available and preferred. They serve as excellent barometers of overall deer impact. In healthy forests, the leaves of these vines can sometimes cover much of the ground surface.

Figure 52. Maple-leaf viburnum is a preferred species that also tends to be widely available. Sherborn, MA.

Figure 54. Heavily browsed basal sprouts of spicebush that are unable to grow above the reach of deer. Sharon, MA.

Figure 53. Winged euonymus is a preferred non-native plant species, as evidenced by this browse line. Boxford, MA.

Figure 55. Heavily browsed basal sprouts of witch hazel that are unable to grow above the reach of deer. Scituate, RI.

Herbaceous Plants

Deer will feed on many kinds of woodland forbs. These include most members of the lily and orchid families and many members of the aster, bean, and rose families.

The profusion of growth in spring represents a time of plenty for deer. The leaves of trout lily and Canada mayflower, which can practically cover the ground in healthy forests, can be depleted over time in deer-impacted forests (figures 56, 57). White trillium, Canada lily, false Solomon's seal, bluebead lily, Indian cucumber-root, and yellow lady's slipper are also preferred (figures 58-60).

American ginseng is preferred by deer and humans alike (figure 61). Wild sarsaparilla, white wood-aster, large-leaved wood-aster, calico aster, bluestem goldenrod, and bunchberry are preferred species that tend to be widely available or locally abundant (figure 62). If at least some of these wildflowers are full-statured and flowering, the deer impact is probably tolerable.

All rattlesnake-root species are preferred. Lion's-foot rattlesnake-root is state-endangered in Massachusetts. Most of its populations in the Commonwealth are suffering deer damage (figures 63, 64).

Hundreds more could be listed here. Pokeweed, for example, is an early-successional forb that colonizes forests disturbed by fire, logging, or blowdown (figure 65). It produces abundant berries that are relished by birds. While rather poisonous to humans, the deer love pokeweed and can all but eliminate it. Its loss to deer browsing has detrimental consequences for wildlife.

Some non-native herbaceous plants are preferred, such as purple loosestrife, but these tend to occur in clearings or other disturbed habitats.

Figure 56. Trout lily can be reduced over time by heavy browse pressure. Cumberland County, ME. (Photo by Roger Monthey)

Figure 57. Canada mayflower, which can cover the ground surface in healthy forests, can be decimated by deer. Oakham, MA.

Figure 58. White trillium, a member of the lily family, is a preferred plant species. Cayuga County, NY.

Figure 59. In deer-damaged landscapes, the functional role of Canada lily in the ecosystem is largely eliminated. (Photo by Isabel Munck)

Figure 62. Browse damage to wild sarsaparilla. Marshfield, MA.

Figure 60. This yellow lady's slipper plant, identified by the hole in its leaf, was found browsed six days after it was initially photographed. Berkshire County, MA. (Photo by Tony Gola)

Figure 63. Photograph of the state-endangered lion's-foot rattlesnake-root, taken on May 18, 2010, at the Blue Hills Reservation, MA.

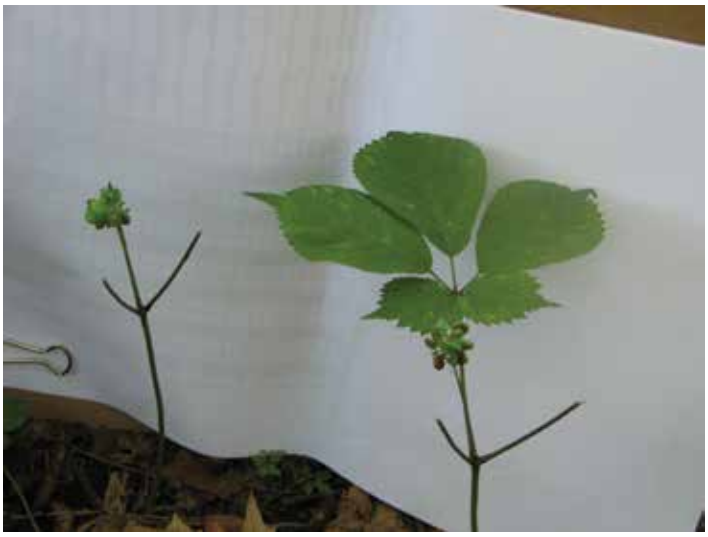

Figure 61. Browse damage to American ginseng. Cayuga County, NY.

Figure 64. A June 11, 2010, photograph of the same plant shown in figure 63. The leaves that were present on May 18 were browsed and replaced by these smaller ones. Blue Hills Reservation, MA.

Figure 65. Pokeweed, a valuable wildlife food plant, can be decimated by overabundant deer. Shelter Island, NY.

Low-preference and Avoided Plant Species

Low-preference and avoided plant species equate to Leopold's emergency and stuffing categories. I simply prefer to use the "low-preference and avoided" terminology. Some researchers refer to these as browse-resistant or browse-tolerant species. These plants are rarely browsed to any great extent in forests with a balanced deer population. As deer density increases, so do the impacts on these species.

Much of the greenery in a deer-impacted forest will be comprised of low-preference and avoided plant species. These plants may have morphological defenses such as thorns, spines, or prickles. They may have chemical defenses that make them unpalatable. Or, they may be avoided for other reasons, for example, deer simply prefer broad-leaved herbaceous plants over narrow-leaved sedges. Low-preference and avoided plants often thrive in the absence of competition from the long-gone preferred species. Some low-preference and avoided plants, selected by the author, are listed in table 2 and discussed on the following pages.

Table 2. Some low-preference and avoided plants in Northeastern forests.

Trees

Abies balsamea	Balsam Fir	*Larix laricina*	Tamarack
Acer pensylvanicum	Striped Maple	*Ostrya virginiana*	Hop-hornbeam
Ailanthus altissima	Tree-of-heaven	*Picea* spp.	Spruce
Betula lenta	Black Birch	*Pinus resinosa*	Red Pine
Betula populifolia	Gray Birch	*Pinus rigida*	Pitch Pine
Fagus grandifolia	American Beech	*Pinus strobus*	White Pine
Gleditsia triacanthos	Honey Locust	*Robinia pseudoacacia*	Black Locust
Ilex opaca	American Holly	*Sassafras albidum*	Sassafras

Shrubs/Vines

Baccharis halimifolia	Groundsel-tree	*Kalmia latifolia*	Mountain Laurel
Berberis thunbergii	Japanese Barberry	*Myrica pensylvanica*	Bayberry
Chimaphila maculata	Striped Pipsissewa	*Rhodotypos scandens*	Black Jetbead
Comptonia peregrina	Sweet Fern	*Rubus phoenicolasius*	Wine Raspberry
Frangula alnus	Glossy Buckthorn	*Solanum dulcamara*	Bittersweet Nightshade
Gaultheria procumbens	Wintergreen	*Spiraea alba var. latifolia*	Meadowsweet
Gaylussacia baccata	Black Huckleberry	*Spiraea tomentosa*	Steeple-bush
Gaylussacia frondosa	Dangleberry	*Symphoricarpos orbiculatus*	Coralberry
Ilex glabra	Inkberry	*Vaccinium corymbosum*	Highbush Blueberry
Kalmia angustifolia	Sheep Laurel	*Zanthoxylum americanum*	Northern Prickly Ash

Herbaceous Plants

Actaea racemosa	Black Bugbane	*Erechtites hieraciifolia*	Pilewort
Ageratina altissima	White Snakeroot	*Euthamia graminifolia*	Grass-leaf Goldenrod
Agrostis perennans	Upland Bentgrass	*Galeopsis tetrahit*	Hemp-nettle
Alliaria petiolata	Garlic-mustard	*Hesperis matronalis*	Dame's Rocket
Amianthemum muscaetoxicum	Fly Poison	*Hieracium venosum*	Rattlesnake Weed
		Lobelia inflata	Indian Tobacco
		Microstegium vimineum	Japanese Stiltgrass
Apocynum cannabinum	Hemp Dogbane	*Monotropa hypopithys*	Pinesap
Arisaema triphyllum	Jack-in-the-pulpit	*Monotropa uniflora*	Indian Pipe
Asclepias syriaca	Common Milkweed	*Osmunda cinnamomea*	Cinnamon Fern
Carex debilis var. rudgei	Northern Stalked Sedge	*Osmunda claytoniana*	Interrupted Fern
Carex pensylvanica	Pennsylvania Sedge	*Packera aurea*	Golden Ragwort
Carex swanii	Swan's Sedge	*Persicaria longiseta*	Chinese Smartweed
Caulophyllum thalictroides	Blue Cohosh	*Persicaria perfoliata*	Mile-a-Minute
Centaurea spp.	Knapweed	*Podophyllum peltatum*	May-apple
Chelidonium majus	Celandine	*Pyrola americana*	Round-leaved Shinleaf
Cinna arundinacea	Sweet Wood-reed	*Ranunculus* spp.	Buttercups
Cirsium spp.	Thistles	*Schizachyrium scoparium*	Little Bluestem
Cynanchum spp.	Swallow-wort	*Solidago rugosa*	Rough Goldenrod
Dichanthelium spp.	Panic-grass	*Symplocarpus foetidus*	Skunk-cabbage
Epifagus virginiana	Beech-drops	*Thelypteris noveboracensis*	New York Fern
Equisetum spp.	Horsetail	*Veratrum viride*	False Hellebore

Trees

All spruces tend to be avoided. Balsam fir, tamarack, and pines are low-preference species (figure 66). In clearings where young pines grow, deer will always favor pitch pine and red pine over white pine. Deer have reached a high population density when their browsing prevents pine or fir regeneration.

Black birch has a chemical defense—methyl salicylate (oil of wintergreen)—that protects it from serious browse damage. Where deer are abundant, black birch is often the only native deciduous tree species that is able to exploit canopy gaps (figure 67). Tree-of-heaven, a non-native species, can also accomplish that feat because of its own chemical defenses. Hop-hornbeam is browsed to a certain extent, but usually not enough to prevent it from growing above the reach of deer. Gray birch tends to be avoided and can quickly grow above the reach of deer.

American beech is regarded as a low-preference species and that is precisely why it is so useful when assessing deer impact. American beech can reproduce clonally from root sprouts. If the beech sprouts are being suppressed, it is a sure sign that the preferred tree species are also being suppressed.

The dynamic between beech sprouts and deer is a clash of ecosystem titans. The sprouts receive abundant energy from their parent tree and are capable of strong growth, even in shaded conditions. But pushing down on them are the deer, browsing the buds and foliage. As deer density increases, the sprouts get shorter. As deer density decreases, the sprouts achieve upward mobility. For the purpose of deer impact assessment, few plants are as useful as American beech (figures 68-72).

Even in forests where the beech sprouts are able to grow above the reach of deer, those forests may still, from a forest management perspective, need further reduction in deer impact. In portions of the Allegheny Plateau, chronic browsing has led to the development of forests dominated by beech and striped maple, trees that are undesirable from a forestry perspective.

While not as choice as many other tree species, sassafras is readily browsed, especially when growing on poor sites surrounded by even less palatable forage. As with beech, sassafras produces root sprouts that can serve as excellent indicators of overall deer impact.

Black locust and honey locust have thorns that deter browsing.

Figure 66. Browse damage to white pine, a low-preference species. Weston, MA.

Figure 67. Avoided by deer, black birch was able to exploit gaps in the canopy. Orange County, NY.

Figure 68. Browse damage to a beech sprout. Kittery, ME. Measuring beech sprout height is a great way to assess changing levels of deer impact.

Shrubs/Vines

Bayberry, sweet-fern, highbush blueberry, black huckleberry, dangleberry, mountain laurel, sheep laurel, northern prickly ash, groundsel-bush, meadowsweet, steeplebush, and inkberry are some low-preference or avoided native shrubs (figure 73). Black jetbead, Japanese barberry, bittersweet nightshade, and wine raspberry are some low-preference non-native shrubs and vines (figure 74). Coralberry, a shrub native from Pennsylvania southward and an escape from cultivation elsewhere, is avoided by deer. Glossy buckthorn tends to be heavily browsed only where deer exist in high densities. Wintergreen and striped pipsissewa are low-preference dwarf shrubs.

Figure 70. In 4 years, the beech sprouts in this deer exclosure have grown waist-high. Shelter Island, NY.

Figure 69. Flowers borne by a deer-browsed beech sprout. This curious phenomenon was observed at two New York locations in 2013.

Figure 71. After 7 years, the beech sprouts depicted in Figure 70 have grown head high. Shelter Island, NY. (Photo by Michael Scheibel)

Figure 72. Some of these beech sprouts are able to grow above the reach of deer, suggesting moderate deer impact in this forest. Westborough, MA.

Figure 73. Inkberry, a distasteful evergreen shrub, is rarely if ever browsed by deer. Braintree, MA.

Figure 74. Wine raspberry, a non-native species, has copious spines that deter browsing by deer. Middletown, RI.

Herbaceous Plants

Native herbaceous plants consistently avoided by deer include skunk cabbage, false hellebore, fly poison, round-leaf pyrola, Indian pipe, pinesap, beech-drops, rattlesnake weed, grass-leaf goldenrod, white snakeroot, common milkweed, and golden ragwort (figures 75, 76). Blue cohosh, may-apple, rough goldenrod, pilewort, Indian tobacco, black bugbane, and hemp-nettle may be browsed to a limited extent or avoided.

With some exceptions, deer tend to avoid feeding on ferns, clubmoss, and horsetails. Bracken fern is one of those exceptions and is a preferred species, especially in the fiddlehead stage. Only in severely deer-impacted forests will browse damage to clubmoss and evergreen fern species be widespread. Sometimes deer will dig into the ground to feed on the underground parts of clonal ferns. While cinnamon fern and interrupted fern are in the same genus and may look alike to us, the deer can distinguish them, by whatever means they use. They will consistently browse cinnamon fern and leave the nearby interrupted fern untouched (figure 77). Some browse damage to interrupted fern has been observed, but only where deer exist in very high densities. As mentioned earlier, hay-scented fern, along with New York fern, can increase dramatically in deer-impacted forests and dominate much of the understory.

Deer avoid most sedges and woodland grasses. Examples include Pennsylvania sedge, Swan's sedge,

Figure 75. The deer that ate this poisonous false hellebore plant must have been in dire straits. Scituate, RI.

Figure 76. White snakeroot possesses toxic qualities and is avoided by deer. Hampshire County, MA.

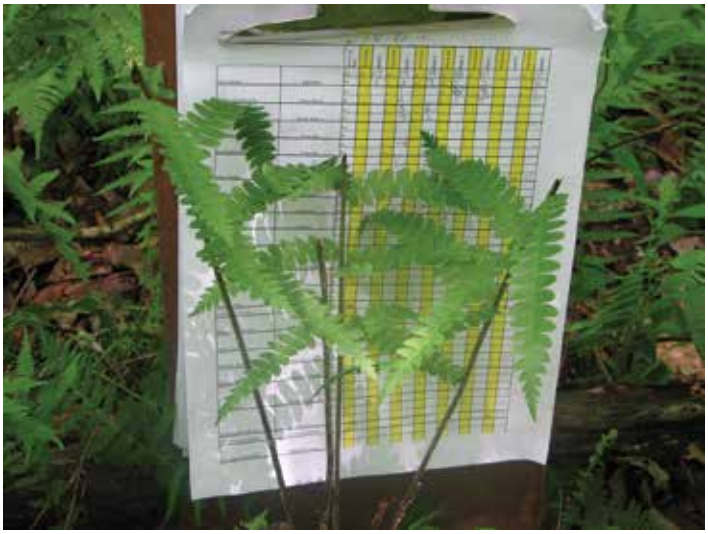

Figure 77. Cinnamon fern is a low-preference species. Deer impacts are high when cinnamon fern is browsed. Scituate, RI.

Figure 78. Pennsylvania sedge, a low-preference species, thrives in this deer-impacted forest. Scituate, RI.

northern stalked sedge, panic-grass, upland bent-grass, little bluestem, and sweet wood-reed (figure 78). A forest understory dominated by grass and sedge is usually diagnostic of high deer impact. Deer will, however, sometimes feed on the young growth of wider-leaved woodland sedge species.

Jack-in-the-pulpit possesses a chemical defense—calcium oxalate crystals—that limits browse damage (figure 79). But where deer densities are high, some browsed stems are easy to find. In exclosures, "jacks" soon grow large enough to produce flowers and fruit, something they rarely accomplish outside of those fences.

Figure 79. Jack-in-the-pulpit can persist but not always thrive in deer-impacted forests. Cortland County, NY.

Non-native herbs avoided by deer include celandine, mile-a-minute, garlic mustard, dame's rocket, common mullein, and swallow-wort.

Invasive plants are often the symptoms, and not the cause, of forest health degradation. Consider the dynamic between Japanese stiltgrass and the native spotted touch-me-not. Both species are annuals and both favor moist soils. Spotted touch-me-not must produce seeds every year for the populations to persist. When fully grown, it can limit the establishment of stiltgrass. But when the touch-me-nots are browsed, they cast less shade and the stiltgrass gains a foothold. Touch-me-not can produce seed from cleistogamous flowers—a "clever" adaptation to browse damage. However, when the deer ultimately eat most or all of the touch-me-nots, the stiltgrass is free to exploit this now-vacant niche (figure 80). In essence, the deer facilitated the success of stiltgrass.

Figure 80. Spotted touch-me-not and Japanese stiltgrass battle for supremacy in this wet spot. Dutchess County, NY.

Exclosure studies have shown that native plants soon outcompete garlic mustard and Japanese stiltgrass when protected from deer browsing.[10] Reducing deer impact may be the best way to achieve landscape-level reductions of these invasive plants. Native plants can beat certain invasives if given a level playing field. This phenomenon has been described as biotic resistance.

In healthy forests, Chinese smartweed, an annual, will be found primarily along woods roads and other disturbed areas. In forests disturbed by deer, the smartweed spreads throughout much of the forest, often with other annuals, biennials, and weedy perennials.

As a final point of interest, many plant seeds consumed by deer remain viable in their fecal pellets. In this manner, deer are dispersing plant species across the landscape.[11]

[10] Knight, Tiffany M.; Dunn, Jessica L.; Smith, Lisa A.; Davis, JoAnn; Kalisz, Susan. 2009. Deer facilitate invasive plant success in a Pennsylvania forest understory. Natural Areas Journal. 29(2): 110-116.

[11] Williams, Scott C.; Ward, Jeffrey S. 2006. Exotic seed dispersal by white-tailed deer in southern Connecticut. Natural Areas Journal. 26(4): 383-390.

Synthesis

Think about all of your observations. What kinds of impact did you see? Which observations were most influential in your assessment? Perhaps deer impacts were judged to be tolerable in one portion of a forest and too high in another. Present your findings in written form, with photographic documentation. Your observations may have raised certain questions that require further investigation. Think about ways to monitor woody plant growth or to census herbaceous plants that might serve as indicator species. Consider testing hypotheses using an experimental design that generates quantitative data. In doing so, you will be proceeding through the scientific method, unlocking the secrets of Nature and contributing information to ecological restoration.

Mitigating Negative Impacts

As a natural resource, white-tailed deer are enormously important. With harvests approaching record levels in many States, deer hunters are enjoying unprecedented success. By traditional measures, wildlife managers should be delighted. And yet, the bounty of venison and recreational hunting opportunities all too often comes at a cost—a cost to native ecosystems, a cost borne by woodlot owners, and a cost understood by people old enough to remember when tick-borne diseases were unknown, when crops could be grown without fencing, and when deer-vehicle collisions were rare. Segments of society enjoy benefits of deer aplenty while other segments are left to pay the associated costs.

At scales large and small, land management is a value-driven balancing act. Working forests, parks, and natural areas may be managed for different purposes, but the overriding concern should always be ecosystem health. Stephen Horsley said it best: [12]

"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 that everyone holds dear."

Wildlife management has evolved over the last century and will continue to evolve to meet new challenges. In much of the country, the challenge today is returning deer densities to ecosystem-friendly levels. To place the well-being of fellow citizens and Nature above personal wants—for the sake of the greater good—speaks highly of a culture that is socially and environmentally responsible (figure 81).

[12] U.S. Department of Agriculture, Forest Service. 2004. The forest nobody knows. Forest Science Review. Issue 1, Winter 2004. Newtown Square, PA: Northeastern [Northern] Research Station.

Figure 81. A tribute to dedicated conservationists. Shelter Island, NY.