US FOREST SERVICE NORTHERN RESEARCH STATION

Research *Review*

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Deer Can Be Too Many, Too Few, or Just Enough for Healthy Forests

Northeastern and midwestern forests are inhabited by large populations of white-tailed deer, the largest herbivore in most of the region (except for moose in the North Woods). Deer populations at the time of European settlement in areas of "prime habitat" (3 million square miles) ranged from 8 to 20 per square mile and seem to have been kept at these levels by a combination of human and wild predation. Later, deer were hunted privately and commercially to near extirpation in much of the eastern forests by the late 1800s to early 1900s. Subsequently, deer were reintroduced and since then populations have increased dramatically across much of the range due to the increased extent of their habitat. In many places the populations are considerably higher than historical levels. This increase has resulted from regrowth of abandoned agricultural lands and forests clearcut for timber, extirpation of top predators (wolves, mountain lions, and bears), as well as rigorously enforced hunting laws designed to keep deer numbers high for modern hunters. Deer are now considered pests in many states, resulting in passionate, polarized public debates by stakeholders with many outlooks—

- Hunters want more trophy bucks and easy hunts
- Animal rights activists don't want anyone to shoot 'Bambi'
- Conservationists, botanists, and wildflower enthusiasts see forests denuded of native shrubs and forbs by deer browsing
- Birders, ornithologists, and entomologists see fewer birds and insects
- Foresters and private and industrial landowners see natural forest seedling regeneration reduced by deer browsing
- Farmers, gardeners, and suburbanites see deer devouring their crops and gardens
- People living in areas of endemic Lyme disease want deer herds reduced to decrease the risk of contracting Lyme disease, babesiosis, and anaplasmosis from deer ticks
- Motorists who crash into deer wreck their cars and are sometimes injured or killed; their insurance rates reflect the millions paid out for car repairs

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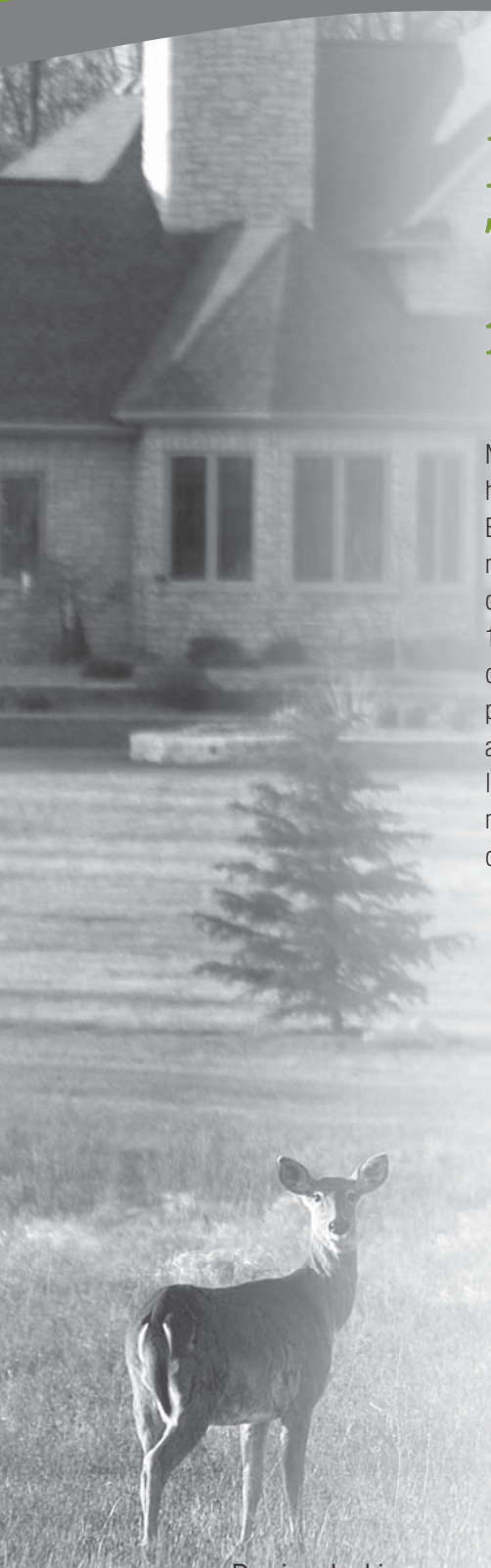

Doe in suburbia.
Photo by David Cappaert, Michigan State University, Bugwood.com

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VARYING DEER DENSITIES LEAD TO DIFFERENCES IN FORESTS

The U.S. Forest Service's Northern Research Station (NRS) scientists at the Irvine (Pennsylvania) laboratory have been studying deer effects on forests since the 1940s, often in northwestern Pennsylvania using the Alleghany National Forest as a typical example of the cherry-maple Alleghany Plateau forest type. Lately, NRS researchers have been running experiments that are pushing the boundaries of the science of deer-forest interactions. Although early research (1942-1975) focused primarily on deer vs. no deer, NRS research since 1979 by Dave Marquis, Stephen Horsley, and Dave deCalesta (NRS retired scientists) and Susan Stout contrasted different levels of deer density in a fenced-enclosure study. In the forested conditions of the study, they found that deer population levels at or below 20 per square mile allowed undergrowth to recover. The study surprised scientists, though, when there was some regrowth even at very high deer densities. Careful examination of the design showed that they had created conditions with very abundant deer forage in the experimental design, that is, they had increased the carrying capacity of the landscape compared to the forest surrounding the enclosures. They began to realize that the same number of deer might be too many in some conditions and just right in other conditions.

TOO MANY DEER

In some places, deer populations are now so high that they cause long-term negative ecological effects, eating out forest understories of wildflowers, shrubs, and tree seedlings. Such forests are pretty obvious—consisting only of tree trunks and a few deer-resistant shrub species. Often, the only understory plant species are native New York and hay-scented ferns and nonnative invasive plants such as barberry, burning bush, and garlic mustard. In areas with high deer densities and little deer forage, the forest may not regrow at all after disturbance, leaving "fern deserts."

Fern desert under northwestern Pennsylvania forest. Scott Stoleson, U.S. Forest Service

Trillium, an indicator species for forest recovery from deer overbrowsing. Joseph O'Brien, U.S. Forest Service, Bugwood.com

In a landscape demonstration project where landowners worked to apply the lessons of the enclosure study, NRS scientists Alex Royo and Susan Stout found that when deer populations were reduced to just-right densities (from about 28 to about 15 deer per square mile in that particular landscape) populations of wildflower indicator species such as trilliums and Canada mayflower started to recover. When NRS partners Tim Nuttle and Ellen Yerger (Indiana University of Pennsylvania), with NRS researchers Scott Stoleson and Todd Ristau, followed up on the sites of the original enclosure study, they found that forests generated under different densities of white-tailed deer had developed contrasting forest tree communities with effects that ricocheted up the food chain of insects and birds (this is what is called trophic cascade) even 20 to 30 years later. Because recruitment of trees from seedlings to the canopy only occurs over a relatively brief (10 years), early period, even short-term variations in deer density may cause centuries-long disruptions to forest ecosystem structure and function.

TOO FEW DEER

Soon after completion of the NRS Pennsylvania deer enclosure study, Horsley and Ristau took a closer look at one species of small tree/shrub, pin cherry, that had become overabundant at the lowest levels of deer density (10 per square mile in that study). They soon realized that this phenomenon was early evidence of such a thing as too few deer. Pin cherry, a shrubby cousin of black cherry (a desirable lumber tree), can out-compete other species when highly abundant.

Meanwhile, in West Virginia, where deer populations were lower compared to the carrying capacity of the landscape, NRS scientists Royo and Mary Beth Adams (Parsons, WV), and Walter Carson (University of Pittsburgh) looked at the effects of interactions of deer browsing, fire, and the creation of gaps in the forest canopy on the forest ecosystem. In fact, this research suggested that the levels of deer were just right for the West Virginia landscape where the study occurred because the mix of disturbances experienced by these forests historically—ground fire, canopy gaps, and some deer—increased diversity, compared to exclosures where there were clearly too few (zero) deer, and the same shrubby plants dominated the understory.

JUST RIGHT LEVELS OF DEER

How do we get and keep deer populations at a reasonable density? In most parts of the East and Midwest, human hunters have replaced the previous natural top predators. Scientific reports of the long-term trophic cascade have resulted in efforts by game commissions and other hunting regulators to encourage hunting of more female deer (does) for meat in addition to trophy males (bucks). When this is successful, the effects of deer browsing are not so severe and forests are healthier—and so are the deer herds. Fewer deer starve in hard winters and they weigh more and are less ridden with parasites.

Howling wolf.
Courtesy of the Wisconsin Department of Natural Resources

In most of the East, the natural top predators of adult deer—wolves and mountain lions—have been extirpated. Bears, which are expanding their ranges into southern New England, are usually predators of fawns but not adult deer. However, in some areas of the Midwest, top predators are not only surviving, but expanding their ranges. Wolf populations in far northern Minnesota have survived and wolves have been recolonizing central Wisconsin since the early 1990s.

University of Georgia scientists Ramana Callan (now at SUNY College of Environmental Science and Forestry) and Nathan Nibbelink and NRS scientist Keith Moser (St. Paul, MN) are analyzing trophic cascade effects. They are looking at whether wolves are reducing local browse intensity by deer and thus mitigating the biotic impoverishment of understory plant communities. Wolf territory data from the Wisconsin Department of Natural Resources combined with USFS Forest Inventory and Analysis (FIA) data were used to develop a landscape-level spatially explicit analysis protocol in FIA plots categorized as high-wolf-impact areas and low-wolf-impact areas. Preliminary results suggest that seedling survival of preferred, browse-sensitive seedlings is higher in areas continuously occupied by wolf packs. Thus, in wilder parts of our forested landscape, the "balance of nature" may be operating again! This phenomenon will be watched closely and studied by wildlife and forest ecologists with great interest.

White-tailed buck in fall.
U.S. Fish & Wildlife Service

BIOGRAPHIES

Todd E. Ristau (*left*) is a research ecologist at the Irvine, PA, lab who is focusing his research on recovery of herbaceous vegetation following forest management and the role of seed banks in vegetation recovery. He received his Ph.D. from the State University of New York College of Environmental Science and Forestry (2010), an M.S. from Penn State (1997), and a B.S. from Houghton College (1991); he joined Forest Service Research in 1991.

Alejandro A. Royo, a research ecologist also at Irvine, PA, focuses his investigations on competition of understory plants and herbivory by deer and small mammals on the diversity and abundance of tree seedlings. He plans on continuing his research on the maintenance of herbaceous species diversity in both temperate and tropical systems. Alex received his Ph.D. in ecology and evolutionary biology and a graduate certificate of Latin American studies from the University of Pittsburgh (2005) and an M.S. and B.S. from the University of North Carolina, Greensboro (1998 and 1993).

Susan L. Stout is a research forester and the project leader of the **Sustaining Forests in a Changing Environment** unit in northwestern Pennsylvania at Irvine. She serves on the Pennsylvania State Bureau of Forestry Ecosystem Management Advisory Council and is an adjunct faculty member of Pennsylvania State University and SUNY College of Environmental Science and Forestry. Stout is collaborating with the Sand County Foundation and landowners in the Kinzua Quality Deer Cooperative to improve both hunting and habitat on 74,000 acres in NW Pennsylvania. She also leads the ongoing development of the SILVAH decision-support software package. She joined the Forest Service in 1981 and has received her Doctorate of Forestry from Yale University (1994), a Master of Science from SUNY (1983), and a Bachelor of Arts from Radcliffe College of Harvard University (1973).

Scott H. Stoleson, (*right*) a research wildlife biologist at Irvine, PA, studies the effects of forest management on the distribution and abundance of vertebrate populations (especially neotropical migrant birds) and quantifies habitat requirements of wildlife communities and species of special concern (such as the cerulean warbler) on the Allegheny Plateau. He received his Ph.D. from Yale University (1996) and his B.A. from Dartmouth College (1979); he joined Forest Service Research in 1997.

Mary Beth Adams is a research soil scientist in the **Ecological and Economic Sustainability of the Appalachian Forest** research unit in Parsons, WV. Much of her current research deals with management and disturbance effects on nutrient cycling in forest ecosystems. She is the principal investigator of the Fernow Watershed Acidification Study, which is using ammonium sulfate fertilizer to study acidification of an entire forested watershed and is also evaluating the role of soil nutrients in sustaining long-term productivity and diversity in Appalachian hardwood forests. Mary Beth received her Ph.D. from North Carolina State University and her M.S. and B.S. degrees from Purdue University.

W. Keith Moser is a research forester in the **Forest Inventory & Analysis** program stationed in St. Paul, MN. Keith prepares standard FIA state reports and conducts hypothesis-driven research using information derived from the FIA datasets. Currently, he is investigating relationships between species and structural diversity versus productivity, patterns of forest response to abiotic and biotic (including nonnative invasive species) disturbances, and different measures of long-term sustainability. He is also part of an international group researching ungulate-forest relationships. Keith received a Doctorate of Forestry from Yale (1994) and a Master of Forestry from Duke University (1986); previously, he had studied management at Duke (M.B.A., 1982) and NC State (B.A., 1980).

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There are 135 NRS scientists working at 20 field offices, 24 experimental forests, and universities located across 20 states, from Maine to Maryland, Missouri to Minnesota.