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Emerging Issues in White-tailed Deer Management and Conservation

February 25-27, 2009
Lafayette, Indiana

Holiday Inn Select Hotel
A unique conference for wildlife and forestry professionals

Conference Sponsors

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Stan Gehrt, Ohio State University
Lenny Farlee, Purdue University, Department of Forestry and Natural Resources
Brian MacGowan, Purdue University, Department of Forestry and Natural Resources
Allen Pursell, The Nature Conservancy
Ron Rathfon, Purdue University, Department of Forestry and Natural Resources
Marne Titchenell, Ohio State University

Acknowledgements

Conference Organizers
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Program
Managing Editor, Ron Rathfon
Publication Designer, Karen Schneider
Cover Designer, Tim Thompson

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Introduction

White-tailed Deer have the ability to change the structure and composition of forests throughout their range. This coupled with their proliferation have led some to term the whitetail an ecological keystone species. However, they are a keystone species in many other ways, including economics, social values and traditions, aesthetics, disease, and more.

How do we manage this keystone species in today's climate? Hunting has been, and will likely continue to be, the primary tool for managing populations of whitetails throughout its range. With the number of hunters and access to areas by hunters continuing to decrease in recent years, do managers need to consider a new approach? Can we maintain populations of whitetails at an ecologically sustainable level? How do we minimize conflict between humans and deer? Are there ways that managers can improve communication with stakeholders and the public regarding deer management?

However, without question the decisions we make today about how to manage deer affect all of us. Conference organizers invited leading researchers from across the country for in-depth look into emerging issues including urban deer management, human dimensions, population management, and more. The purpose of this conference was to facilitate dialogue and new ideas related to the most critical issues in white-tailed deer management. The conference organizers do not profess all questions have been answered. However, we hope this conference will foster communication among stakeholders and ignite research and partnerships to address sustainable white-tailed deer management. In fact, an argument could be made that the real emerging challenges to white-tailed deer management and conservation aren't the issues themselves that managers and society face, but perhaps the manner in which they face them.

Conference Program

Wednesday, February 25, 2009

10:00—noon	SAF Executive Committee (Boardroom)
1:00—3:00	SAF Business Meeting (Pitman A)
1:00—3:00	TWS Business Meeting (Pitman B)
3:00—6:00	Registration (Lobby)
6:00—10:00	Evening Mixer/Social (Grand ballroom and Mezzanine)

Thursday Morning, February 26, 2009

7:00	Continental Breakfast (Mezzanine)
8:00	***Introduction and Welcome*** Allen Pursell, The Nature Conservancy
8:15	***Challenges of Deer Management from an Ecosystem Perspective*** Gary Alt, President, Gary Alt Consulting, Lagunitas, CA
9:15	***Suburban Deer Management : Integrating Lethal and Non-lethal Approaches*** Jay Boulanger, Cornell University, Ithaca, NY
10:00	Break (Mezzanine)
10:30	***Quality Deer Management – Application in the Midwest*** Kip Adams, Northern Director of Education & Outreach, Quality Deer Management Association, Knoxville, PA
11:15	***How Can Emerging Diseases Impact Deer Management?*** Successes and failures of disease management in wildlife – Chronic Wasting Disease (CWD) in Wisconsin as an example. Tim Van Deelen, University of Wisconsin, Madison, WI
Noon	Lunch (Ballroom)

Thursday Afternoon, February 26, 2009

12:45 **Poster Session** (Mezzanine)

Session Moderator: Lenny Farlee

1:15 ***Indirect Effects of Overabundant White-tailed Deer in Forests: Suppression of Unbrowsed Native Species and Facilitation of Invaders***
Susan Kalisz, Dept. of Biological Sciences, University of Pittsburgh, Pittsburgh, PA

2:00 ***Treating the Problem and Not the Symptoms: Fertility Control in Urban Deer***
Jay Kirkpatrick, Science and Conservation Center, Billings, MT

2:45 Break (Mezzanine)

3:15 ***Overbrowsing Legacies in Forest Understories: Results From Small- to Large-Scale Experiments in Pennsylvania.***
Alejandro A. Royo, USDA Forest Service, Northern Research Station, Irvine, PA

4:00 ***Strategies in Changing Management Paradigms and Policies in Pennsylvania, 1999-2004***
Gary Alt, President, Gary Alt Consulting, Lagunitas, CA

4:45 ***Suburban Encroachment: Or How to Educate the White-tailed Deer to Obey Traffic Signals***
Rick Ainsworth, CPCU, AIC, AIM; Manager, Relations and Staff Development, Indiana Farm Bureau Insurance, Indianapolis, IN

5:30 Adjourn

6:30 **Dinner (**Ballroom)

Speaker, T. Edward Nickens, editor-at-large, *Field & Stream*; and contributing editor of *Audubon*

Friday Morning, February 27, 2009

7:00 Continental Breakfast (Mezzanine)

Session Moderator: Marne Titchenell

8:00 ***How Should We Respond to More Deer, Fewer Hunters and Less Access?***
Delwin E. Benson, Colorado State University, Fort Collins, CO

8:45 ***The Dynamics of White-tailed Deer Demographic and Movement Patterns Throughout the Midwest***
Rique Campa, Michigan State University, East Lansing, MI

9:30 ***A Tug of War: Human Dimensions of Deer Management in the Midwest***
Shawn Riley, Michigan State University, East Lansing, MI

10:15 Break (Mezzanine)

10:45 ***Deer Management Issues for State Government***

Rod Clute, Michigan Department of Natural Resources
Tom Micetich, Illinois Department of Natural Resources
Chad Stewart, Indiana Department of Natural Resource

11:50 **Closing Remarks**

12:00 **Adjourn**

Oral Abstracts

Challenges of Deer Management from an Ecosystem Perspective

Dr. Gary Alt
Gary Alt Consulting, Lagunitas CA
Thursday, February 26 at 8:15 am

Restoring white-tailed deer to their previous range in the early 1900s, after being eradicated from many areas during a century or more of overexploitation, has often been touted as one of wildlife management's greatest success stories. Ironically, now, after decades of overprotection, one of the greatest challenges of wildlife management is to balance this important game species with its forest habitat. Winning support of recreational hunters to reduce deer populations to levels compatible with forest ecosystem management is a critical challenge with important consequences, not only to solving this conflict, but to the future of recreational hunting as well. Further exacerbating this problem is the declining numbers of hunters, their increasing age, lower mobility, and declining land access to hunt. The health and sustainability of forest ecosystems will likely be dependent on increasingly aggressive strategies to bring deer populations in balance. If this challenge is not met, and conflicts between deer and society continue to grow, alternative, untraditional solutions are likely to follow.

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Suburban Deer Management: Integrating Lethal and Non-lethal Approaches

Dr. Jay Boulanger,
Cornell University, Ithaca NY
Thursday, February 26 at 9:15 am

Control of white-tailed deer (*Odocoileus virginianus*) population densities and associated impacts in suburban landscapes has included alternative management techniques such as sharp-shooting, controlled hunting, trap and relocation, hormone regulation, and immunocontraception. However, these management techniques are often stymied by costs, political impediments, or inefficiency. We are implementing the novel use of surgical sterilization in combination with hunting to mitigate deer-related impacts on Cornell University lands and surrounding neighborhoods. For this study, Cornell lands have been divided into two zones: a suburban core campus area (721 hectares) and adjacent outlying areas that contain agricultural fields and natural areas where deer hunting is permitted (582 hectares). Surgical sterilization is the primary technique used in the core campus zone; increased harvest of female deer through an "Earn-a-Buck" program is implemented in the hunting zone. In both

zones, concomitant use of temporary electric and other fencing designs will be used to protect research plots and natural areas. Infrared-triggered cameras (IRCs) are being used to estimate deer abundance and survival rates. In the hunting zone, deer populations will be monitored using a deer sighting log and by data collected at a mandatory deer check station. Ongoing deer browse and deer-vehicle accident (DVC) monitoring will also help ascertain deer impact levels throughout the study. The results of this research could determine if fertility control is a viable, long-term approach to managing deer or other wildlife populations.

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Quality Deer Management— Application in the Midwest

Kip Adams
Quality Deer Management Association. Bogart, Georgia
Thursday, February 26 at 10:30 am

Increasingly, hunters, landowners and wildlife managers across North America are embracing the quality deer management (QDM) philosophy. This is evidenced by the rapidly increasing implementation of QDM practices on both private and public lands. Hunters are rethinking what constitutes a “quality” hunt and how they can make a positive contribution to the future of deer hunting and management. Quality deer management is a management approach that produces healthy deer herds with balanced adult sex ratios and increased numbers of older bucks. This approach typically involves protection of young bucks and active harvest of female deer to maintain herds within existing habitat conditions. I’ll describe how QDM programs can be tailored to Midwest deer herds and habitats, and how a QDM approach can help Midwest wildlife agencies achieve their deer management goals.

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How Can Emerging Diseases Impact Deer Management?

Dr. Timothy R. Van Deelen
Department of Forest and Wildlife Ecology
University of Wisconsin – Madison
Thursday, February 26 at 11:15 am

Co-authors: Robert E. Rolley and Christopher N. Jacques, Wisconsin Department of Natural Resources.

In March 2002, the Wisconsin Department of Natural Resources announced that Chronic Wasting Disease (CWD) had been identified in three hunter-killed deer brought to a check station near Mt. Horeb in south-central Wisconsin. This event marked the first time that the disease had been identified in free-ranging white-tailed deer east of the Great Plains and sent a shockwave rippling through the communities of hunters, managers, and researchers whose personal and professional lives were invested in the well-being of the high-density, high-productivity, deer herds of the Midwest and Northeastern United States. CWD was (and is) an obscure disease whose unique prion-based etiology makes it difficult to study and unlike other familiar diseases caused by bacteria and viruses. In the face of uncertainty and a judgment that the high density conditions of free-ranging deer in eastern ecosystems would foster enhanced transmission, managers in Wisconsin acted aggressively to reduce disease prevalence where it had been identified, survey the state to determine the spatial extent of the outbreak, and begin a research program to better understand CWD dynamics. Management of the disease itself took the form of three goals: 1) disease eradication based on depopulation of the known outbreak area to remove diseased deer and uninfected deer needed to sustain the outbreak, 2) aggressive population reduction in a buffer zone surrounding the outbreak to reduce the probability that deer moving from the outbreak area could cause a new outbreak, and 3) a state-wide ban on the practice of baiting and feeding deer to remove an important human cause of close contact in wild deer. Six years later, none of these goals have been achieved as success towards 1) and 2) appears increasingly unlikely. Research during the six years has expanded our knowledge of CWD dynamics but has failed to produce the “silver bullet” that would make control of this disease easier. Indeed research suggests that control, if it will happen at all, will require extraordinary changes in the way deer and deer hunting are managed. Managers have been criticized for unnecessarily fostering a crisis mindset and acting in a top-down authoritarian manner that alienated hunters and landowners causing them to withdraw or withhold their support for disease eradication measures. Conversely, landowners and hunters were unwilling to accept changes to their traditional ways of hunting and unable or unwilling to accept that the longer term health of the region’s deer herd may need to be traded off against their short-term interest in recreational hunting of abundant deer locally. Hence, we are at something of a stand-off exacerbated by uncertainty that has existed all along, as well as by new antipathies, cynicisms and distrust. Unless this standoff is resolved, CWD may spread through-

out Eastern and Midwestern deer populations making eradication and containment even less likely.

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Indirect Effects of Overabundant White-tailed Deer in Forests: Suppression of Unbrowsed Native Species and Facilitation of Invaders

Dr. Susan Kalisz
University of Pittsburgh, Pittsburgh, Pennsylvania
Thursday, February 26 at 1:15 pm

It is now clear that when white-tailed deer are overabundant, they cause the decline of their preferred food plants in forests. However, our results from both long-term replicated experimental deer exclusion plots and forests sites with a wide range of deer densities reveal dramatic indirect effects of overabundant deer on two components of the understory community.

First, we tested for indirect effects of deer on plant species that they rarely browse. We found surprising changes in population structure and demography of *Arisaema triphyllum* (Araceae) in highly browsed sites in Pennsylvania relative to sites with lower browse levels. Reduced growth rates, plant size, and seed rain, a lower proportion flowering adults, and increased male-biased sex ratios in *Arisaema* populations were all significantly correlated with deer browse on a co-occurring palatable species. We found that the differences in plant size for *Arisaema* and four other unbrowsed herbs growing in paired deer exclusion/access experimental plots in Virginia showed identical results—unbrowsed plant species are smaller where deer have access relative to the deer exclusion plots. Across both the PA and VA sites, soil compaction is significantly lower where deer browse was lower (PA sites) and in deer exclusion plots (VA sites). Soil compaction is known to slow plant growth and decrease mycorrhizae hyphal growth suggesting an indirect mechanism influencing *Arisaema*'s and the other non-browsed species performance declines.

Second, we tested for deer facilitation of invasive plant species spread in forests. We quantified the population growth rate (l) of the noxious invader, *Alliaria petiolata* (Brassicaeae) in paired deer exclusion/access experimental plots in PA. We found consistently high (l>1.5) across three years in the presence of deer. In contrast, population growth rate decreased significantly in deer exclusion plots and populations are in decline. Further, densities of adult plants declined significantly in the exclusion plots, but remain high in the deer access plots.

Summary: Our studies indicate that 1) many unbrowsed species in forests with high deer densities could be negatively affected along with their palatable neighbors and 2) deer facilitate the invasion of the forest by *Alliaria*. Together, these results implicate high deer density in the cascade of plant species decline and invasion in forests and highlight the urgency of this conservation issue.

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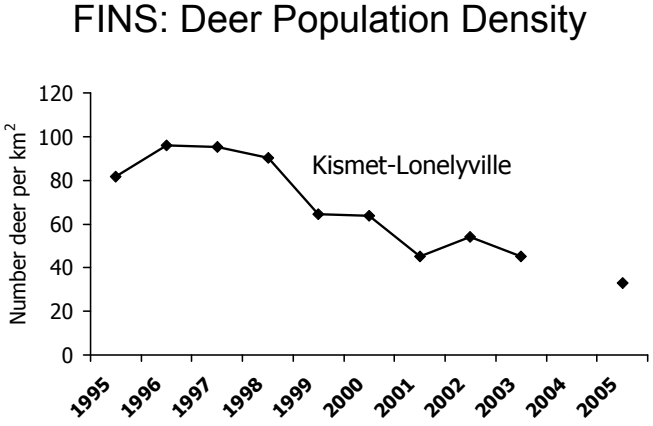
Treating the Problem and Not the Symptoms: Fertility Control in Urban Deer

Dr. Jay F. Kirkpatrick
The Science and Conservation Center, ZooMontana, Billings, Montana
Thursday, February 26 at 2:00 pm

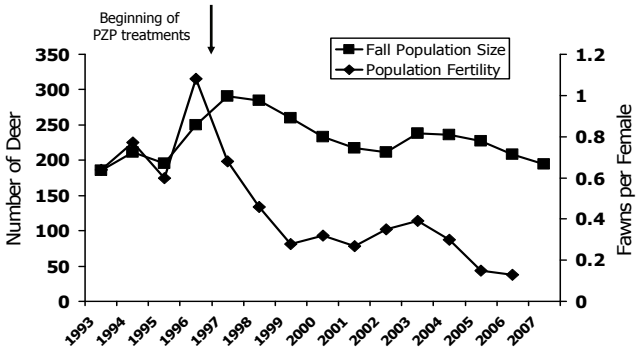
Fertility control has been demonstrated to be a successful approach to the management of certain urban deer populations. Population growth in two large typical urban populations of white-tailed deer has been stabilized and even reduced through the application of contraception. Along with white-tailed deer, controlled studies with 12 additional species of cervids and 56 species of artiodactylids have documented both safety and efficacy, and extensive studies with free-ranging equids and African elephants have validated the ability to stabilize population growth in wary free-ranging wildlife. Opposition to this approach is based in social, political and cultural issues, and in the absence of empirical data and valid biological concerns.



(Data from Naugle et al. 2002; Underwood 2005; Underwood, pers. comm.)

Population density trends in the Kisment-Lonelyville segment of Fire Island National Seashore (FINS), 1995-2005. Contraception began in autumn 1993, but no population data are available before 1995. (From and Rutberg and Naugle. 2008 Wild. Res. 35: 494-501)

NIST: Fertility Rates and Population Size



Autumn population size (squares and dashed line) and population fertility in fawns per female (diamonds and solid line) at National Institute of Standards and Technology (NIST). (From and Rutberg and Naugle. 2008 Wild. Res. 35:

Dr. Jay F. Kirkpatrick, Director, The Science and Conservation Center, 2100 South Shiloh Road, Billings, MT 59106, Phone: 406-652-9719, Email: jkirkpatrick@montana.net

Overbrowsing Legacies in Forest Understories: Results from Small- to -Large Scale Experiments in Pennsylvania

Dr. Alejandro A. Royo
USDA Forest Service, Irvine, Pennsylvania
Thursday, February 26 at 3:15 pm

In eastern North America, chronic white-tailed deer (*Odocoileus virginianus*) browsing has drastically altered plant diversity patterns in forest understories. In Pennsylvania, deer reintroductions and subsequent overprotection resulted in a rapid recovery of deer populations from near extirpation in 1895 to nearly one million animals by the 1920s. This history of overabundant herds provides a unique opportunity to investigate the long-term impact of deer overbrowsing on forest biodiversity and successional patterns. Here, I summarize results from various investigations in Pennsylvania's northern hardwood forests, including observational approaches, small- and large-scale experiments and landscape-level studies that highlight the various deleterious impacts of overbrowsing on forest diversity. Observational and experimental work repeatedly demonstrate that chronic browsing directly lowers understory plant abundance, growth, and reproduction, at times driving browse-sensitive species to local rarity and restricting their occurrence to inaccessible refugia. Prolonged overbrowsing also tends to shift forest understory composition to dense, nearly monodominant layers of highly browse-tolerant plants. This radical shift in un-

derstory composition alters subsequent plant-plant competitive interactions as this stratum strongly suppresses germination and survival of shade intolerant tree species. Finally, this widespread habitat modification indirectly modifies other herbivore-plant interactions, including intensifying seed predation by small mammals. Overall, we suggest the legacy of a century-long hyper-abundant deer herd is a depauperate forest community with strengthened competitive and granivory regimes. These changes to forest understory dynamics are so pronounced that considerable efforts will be required to reverse the current momentum toward continued biotic impoverishment.

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Strategies in Changing Management Paradigms and Policies in Pennsylvania, 1999-2004

Dr. Gary Alt
Gary Alt consulting, Lagunitas, California
Thursday, February 26 at 4:00 pm

The most sweeping policy changes in Pennsylvania deer management history occurred between 1999 and 2004. Pennsylvania's traditional rifle deer seasons consisted of a two-week "buck" (antlered only) season followed by a three-day "doe" (antlerless only) season, which typically produced antlerless harvests inadequate to balance deer populations with their forest habitat, resulting in undesirably low survival of antlered bucks. To rectify the underharvest of antlerless deer, antlerless allocations and sales were increased from about 600,000, to over a million; hunters were allowed to buy up to three antlerless licenses, instead of just one; the two-week "bucks only" season was converted to an either-sex season; an October antlerless season was created and a Deer Management Assistance Program (DMAP) was created. To increase survival of antlered bucks, antler restrictions were changed in 2002 from a spike, three or more inches in length, to requiring three or more points on one side in much of Pennsylvania, and four or more points on one side in the areas of best habitat. These changes resulted in their intended effect with an increase in average antlerless harvests by about 100,000 and a reduction in the buck harvest by roughly 50,000. Political climate and public attitudes were important in determining when and how much policy could be changed. Selection of a competent team of scientists and providing them with a stimulating and safe meeting environment to evaluate existing programs, design research, and make policy change recommendations were critical. An intense and large-scale outreach campaign, during the public comment period, was one of the most critical actions to successfully change policy.

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Suburban Encroachment: Or How to Educate the White-tailed Deer to Obey Traffic Signals

Dr. Rick Ainsworth
Indiana Farm Bureau Insurance, Indianapolis IN
Thursday, February 26 at 4:45 pm

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How Should We Respond to More Deer, Fewer Hunters and Less Access?

Dr. Delwin E. Benson
Colorado State University, Fort Collins, Colorado
Friday, February 27 at 8:00 am

Hunting public deer on private lands managed by governmental rules creates dilemmas for about two-thirds of lands in the United States. Private persons with ownership and responsibility for the land do not have authority for wildlife management. Government persons who have authority for wildlife management do not have responsibility or even access to the private lands. Persons who produce wildlife are expected to be responsible, but not enabled to address the costs.

Our history of government authority for wildlife conservation is well-established in North America. Government will likely continue to play a major role in wildlife conservation, whether attributed to public trust obligations or simply from a tradition of regulatory authority. But inflexibility by government conservationists to share authority and responsibility with the private sector discourages opportunities for wildlife conservation on private land. This attitude has been an impediment to the growth of systems that enfranchise private landowners to manage their land positively with the objective of wildlife for societal benefits. Cooperative management systems offer solutions to this problem. Public-private partnerships that encourage landowners with incentives and assistance, while preserving the oversight necessary for government to fulfill its trust responsibilities, offer the best hope of maintaining healthy landscapes, wildlife populations, and recreational opportunities on private land.

Governments cannot manage private lands alone. Rules and even incentives coming from governments are not as effective as are the internal motives and personal controls that are in the hearts and hands of the private sector. Employees of governments can encourage conservation visions and help towards land ethics and stewardship practices. Landowners should become partners with governments, if the majority of lands have a place in conservation. Going separately or alone has not made enough progress to date, so there must be better ways.

Private lands are the new frontier for conservation initiatives. Public lands and public agencies have neared a threshold of expectations and accomplishments. There might be fewer governmental influences in the future with fewer hunters, anglers, visitors to parks, and kids in the woods resulting in financial problems at local, state, and national levels. Elsewhere in the world, governmental agencies play lesser roles in conservation. If governmental influences wane in the United States, the needs for nature conservation on private lands will not disappear. The next steps for conservation require the work of private partners and the forging of cooperation among agencies, organizations, and landholders.

Opportunities for nature conservation on private lands are on the rise and so should be the solutions. Land uses are changing. Fewer acres and fewer agricultural producers are needed to produce an increasing percentage of crop yields. Agricultural lands are often purchased for natural resources and aesthetic values instead of commodity production. The new owners may not have long family histories with the land and associated knowledge, skills, and attitudes, but they have strong passions. They have interest in conservation and may have money to spend. They can use help. Other private lands are developed and the open landscapes once used for crops, livestock, and hunting are replaced with cities, small acreage developments, and urban deer problems. Private landholders control the outcome of lands that they occupy and they must become part of modern conservation.

Let us recognize that public resources need private solutions; and, to cooperate with landholders is smarter than to debate who is in charge. While we debate, deer numbers and landowner angst increase while hunting opportunities and access decrease. Seven thoughts and a conclusion follow.

1. Two-thirds of the United States is private; most public land is in the West; and the rest of the United States is mostly private. Governments cannot fully affect that which they do not control. Governments can take over private ownership--which is not politically or economically likely--or they can enfranchise the private sector to act on the people's behalf.

2. If lands remain private, then governmental employees cannot be sure what happens behind the private fence. If fish, wildlife and the environment across the private fence are important to society, then we must work with the private sector to develop mutual trust and mutually beneficial programs.

3. Evolution of the Public Trust Doctrine, which formed bureaucracies and experienced governmental success with the initial needs of landscape and animal management, has now incorrectly prompted thinking that governmental action is the only action needed or possible.

4. A more appropriate application of governments' custodial role, empowered by the public trust, enables us to represent government by working with the people to encourage and enfranchise their hand in conservation.

5. Governments must use caution not to become the sovereign kings of old--who own the wildlife and parcel it out to the commoners on their terms only. It

is contrary to the Public Trust Doctrine when employees of governments dictate too broadly who can participate in conservation and who cannot.

6. Access to private lands has never been easy and has become increasingly difficult as more users are urbanized without local contact to rural lands and as landowners want a voice in decisions about their own property.

7. Sportsmen can pay more for production and management. In 2006, hunters and anglers paid most of their money for their trips and equipment (86%) not for the resources that make hunting and angling possible. Payments for magazines, membership dues, contributions, land leasing and ownership, and licenses, stamps, tags, and permits accounted for only 14% of expenditures. Hunters used private land exclusively 58% of the time and both public and private 82%. Only 15% of hunters used public land only. Data were taken from U.S. Department of the Interior, Fish and Wildlife Service, and the U.S. Department of Commerce Census Bureau. (2006 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation).

Cooperative approaches promoting a public and private trust for conservation are not new and have roots with the nation's leaders of conservation. Teddy Roosevelt correctly forecast a combination of public and private preserves and shooting grounds in 1909 according to Aldo Leopold (1933:18). Following in Roosevelt's legacy, which set aside public land reserves, Leopold advocated a role for public and private sectors over the next 40 years until his death (Leopold 1930, 1933, 1949). Perhaps Leopold's most relevant question was when he asked us "How shall we conserve wild life without evicting ourselves?" (1933:19). Landholders and governmental employees should ask that question with each of their decisions.

Presentations at venues like this should concentrate on building mutual trust, instilling obligations for a stewardship ethic by public and private sectors, and creating enfranchisement mechanisms that enable the private sector to contribute towards personal and societal conservation practices and growth. The public means everyone, but some publics, such as landholders, possess greater influence and affect greater consequences on the land. Consequently, we must work with landholders because their lands are important, it is right to do so, and pragmatically, because the private sector has great control over lands which they possess and to which they control access. Sixty years after Leopold, we still debate the merits of entrusting responsibility within the private sector. There should be no question about "if," the question is "how?"

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Dr. Delwin Benson, Colorado State University, Department of Fishery and Wildlife Biology, 109 Wagner, 1474 Campus Delivery, Fort Collins, CO 80523-1472, Phone: 970-491-6411, Fax: 970-491-5091, Email: delwin.benson@colostate.edu

The Dynamics of White-tailed Deer Demographics and Movement Patterns Throughout the Midwest

Dr. Henry Campa, III
Michigan State University, East Lansing, MI
Friday, February 27 at 8:45 am

Co-authors: W. David Walter, Kurt C. Vercauteren, William R. Clark, Justin W. Fischer, Scott E. Hygnstrom, Nancy E. Mathews, Clayton K. Nielsen, Shawn J. Riley, Eric M. Schauber, Timothy R. Van Deelen, and Scott R. Winterstein.

(*Odocoileus virginianus*) now represent a challenge facing communities and natural resource managers in the 21st century. Once a wildlife resource of interest only to hunters and state management agencies, deer are now of widespread interest to the general public. As a result of increases in the distribution and abundance of white-tailed deer, stakeholders throughout the Midwest and Northeast Regions of the United States incur numerous positive and negative effects. For example, as a result of events such as herbivory on commercial crops and ornamental vegetation, deer-vehicle collisions, and outbreaks of bovine tuberculosis and Lyme disease, stakeholders incur economic, psychological, and health-related impacts. Concurrently, deer provide positive economic, recreational, and aesthetic attributes such as recreation from hunting, viewing of wildlife, and can serve a significant role in ecosystems functions. Balancing the positive and negative impacts of deer on the environmental and social landscapes requires increased knowledge about stakeholders and the ecological relationships between deer and their environment.

A great deal has been learned about white-tailed deer in the last few decades. However, the ability to control deer numbers has not kept pace with the growth and expansion of deer populations in many areas. Very little empirical data exist on deer population distributions and dynamics at large scales, nor have researchers adequately attempted to investigate the ways habitat and population management can affect deer populations at these scales across the Midwest. For example, do deer in landscapes dominated by agricultural crops use woodlots as refugia during difficult winter periods or as metapopulation activity centers and as a result influence crop production and forest characteristics? In more southern states, because of mild fall and winter conditions, are deer more widely distributed among many different vegetation types? How can deer populations be regulated at the landscape scale under changing human demographics? And lastly, can deer population and habitat management programs be designed to affect the distribution and abundance of deer to meet management objectives? Just as there are questions about how landscapes throughout the Midwest influence deer distributions, there are also many questions regarding how landscape characteristics influence deer population structure and demographic processes.

Increased knowledge about white-tailed deer ecology and stakeholder values about deer are needed to match the level of acceptable impacts with capabili-

ties of deer management. Specific needs include determining: (1) the landscape scale factors affecting the distribution and abundance of white-tailed deer throughout different types of landscapes; (2) stakeholder-defined impacts desired from deer, and factors affecting the willingness of stakeholders to accept impacts from deer; and (3) changes necessary in land management, education, communication, and hunting regulations to enhance the effectiveness of wildlife management.

To address these research topics, a multi-state (Illinois, Michigan, Nebraska, Wisconsin) regional project was developed in 2002 (http://nimss.umd.edu/homepages/history.cfm?trackID=2074). A basic premise of this project was that deer population density, demographic rates, management, and stakeholder acceptance capacity would vary across a continuum of landscapes. In particular, we expected these ecological and management characteristics to vary with the relative proportion of potential deer habitat, particularly the ratio and types of forests and cropland. Many of these ecological and management characteristics would reflect the state-specific historic pressures to which human and deer populations have been exposed. Therefore, many of the factors to be examined do not vary enough within one state or are too confounded within the state to allow for valid state-by-state comparisons. To achieve the necessary level of variability and replication of characteristics, large landscapes were required. Additionally, given the size of the required study sites and costs associated with collecting data on these sites, no single state can afford the required replication. The goal of this project was to improve the capabilities of state wildlife management agencies, local governments, and other stakeholders to make decisions about the management of white-tailed deer throughout the Midwest. To achieve this goal, improved understanding is needed about the effects of landscape characteristics on the biological, environmental, and human dimensions of white-tailed deer management. Initiating a multidisciplinary, multi-state collaboration among researchers that addresses these specific needs is essential to comprehensively assess and manage the white-tailed deer in diverse regions throughout the United States.

We found that for resident female deer, annual size of home range in Illinois (0.99 km^2), Michigan (0.77 and 1.34 km^2), Nebraska (1.20 km^2), and Wisconsin (1.47 km^2) did not differ across the region, but differences between agricultural growing and nongrowing periods were apparent. Influential landscape variables included distance to forest, roads, and urban development from the centroid of deer home range, and percent of cropland along with four landscape pattern indices (contrast-weighted edge density, mean nearest neighbor, area-weighted mean shape index, and patch size coefficient of variation). We also identified differences in model selection for four spatial scales created hierarchically to reflect levels of landscape connectivity determined from the perspective of deer. The relatively small annual home ranges of deer in some states may be attributed to land ownership patterns, quality of the habitat provided by stakeholders, and the positive values stakeholders have for deer. Patterns of habitat quality across the landscape and the positive impacts stakeholders experienced from deer may also contribute to the high annual survival in some landscapes (e.g., Michigan). Connectivity of selected forested regions within

agro-forested ecosystems across the Midwest may play a more prominent role in understanding the size of home ranges than traditional definitions of deer habitat. Knowledge of deer behavior and landscape characteristics should be considered for making effective deer management decisions in the future.

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A Tug of War: Human Dimensions of Deer Management in the Midwest

Dr. Shawn J. Riley
Michigan State University, East Lansing, MI
Friday, February 27 at 9:30 am

I draw on several recent studies in Michigan and New York to illustrate how changes in habitat, deer, and human populations have created a tug-of-war among and between stakeholders and wildlife management agencies, and even a tug-of-war within individual stakeholder groups. In southern Michigan, deer hunters are the only stakeholders who want more deer than currently exists. Yet, even among deer hunters, tug-of-wars carry on over characteristics of the deer resource (e.g., abundance, age distributions, and configurations of antlers), harvest regulations (e.g., antlered-buck only, antler point restrictions, antlerless permits) or method of take (e.g., archery, rifle/shotgun, black powder seasons). In some areas of the Midwest a new tug-of-war exists between which predator – wolf or human – have primal rights to deer. Meanwhile, many other stakeholders living with deer seek relief from impacts created by deer herbivory, deer-vehicle collisions, and risks from disease. Even among non-hunting stakeholder groups or even within the same individual stakeholder group discordance exists, when one of the reasons people identify for living in rural areas is to interact with wildlife while others in the same area identify interactions with deer as one of the greatest risks from living on the rural landscape. In some cases, a tug-of-war exists over who is responsible for creating certain effects from deer, such as deer-vehicle collisions. Indeed, a tug-of-war may even exist within the paradigms of wildlife management. That is, a paradigm of protection and distribution of a scarce deer resource among a limited number of constituents (conventional game management) is being pulled on the other end by a paradigm of managing impacts created by deer to a larger stakeholder community (an emerging paradigm). Coincidental with increases in deer distribution and abundance are a decrease in the number of hunters and a decrease in capacity to control deer populations through antlerless hunting. This situation is only expected to be exacerbated with the onset of additional diseases in deer and any other factor that diminishes hunter participation. No easy solution is apparent. Solving the dilemmas, or ending the tug-of-wars, likely will require bringing together an array of disciplines such as city and regional planning, communication, economics, education, sociology, social psychology, and wildlife ecology. No other area of wildlife management will require more integrative thinking than

that involved in management of white-tailed deer. I present a simple concept map that depicts the current situation and suggest a framework to promote integrative thinking.

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Poster Abstracts

A Model Deer Management Program at Allerton Park: Requiring Hunters to Volunteer

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Controlled hunting programs are becoming increasingly necessary on state nature preserves, county forest preserves, and urban municipal properties. These programs are often met with safety concerns, stereotypes of “evil” hunters, and animal rights activism. The decision to take lethal action is never popular and management programs are always under close public scrutiny. It is very important that controlled hunts are conducted safely and successfully. Organizations, urban or rural, have to face deer overabundance, and on a shoe-string budget. Budgetary limitations typically favor controlled hunting over more costly professional sharpshooters. On 1,500 acres, the Allerton Park deer management program harvests an average of 125 deer each year using a small number of dedicated bowhunters. Each bowhunter is required to donate 40 hours of volunteer service to the park, in 2007 from deer hunters, Allerton Park received more than 2,500 hours of volunteer service worth an estimated $48,347. By requiring volunteer service, our hunting program attracts high-quality individuals; since implementing the requirement, regulation violations have been reduced to nearly zero. Furthermore, the average bowhunter is a skilled worker; we receive labor from contractors, information technology specialists, painters, carpenters and more. Additionally, hunters have helped clear acres of exotic species from the park, a task which provides hunters a better understanding of why deer management is necessary from an ecological point of view. Most importantly, hunters continue to produce harvest numbers substantial enough to maintain the deer population near our target population level.

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Aerial Surveys of the Future: Forward Looking Infrared (FLIR) vs. Traditional Visual Surveys

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White-tailed deer population surveys are conducted by flying in a helicopter over the target deer herd following a fresh snow, allowing for ideal visual contrast between deer and the ground. With the increasing number of organizations wanting to conduct deer surveys, a limited number of helicopters, and the reduction in substantial winter snow events, it is becoming increasingly difficult to estimate deer populations through visual aerial surveys. Forward Looking

Infrared, or FLIR surveys are becoming increasingly popular and, in some cases, are thought to be equally as accurate as. or more accurate than visual surveys. FLIR utilizes an infrared camera to detect objects in the environment emitting infrared heat. Between December 2007 and March 2008 we conducted eight aerial surveys of two different deer herds, the Allerton herd, which was under intensive deer management, and the Cerro Gordo herd, which was unmanaged. Weather determined if we conducted visual surveys or FLIR; visual surveys were conducted when snow was present, while FLIR was used when snow was not present. We tested the two techniques back-to-back on a day when snow was present, discovering that deer beds among snow appear as live deer, resulting in overestimates of population numbers. FLIR can not be accurately used over snow. The two techniques were compared in respectively ideal conditions within 48 hours of each other. Our population estimates varied substantially, however differences were more related to weather events than survey method. Visual surveys and FLIR surveys can be used interchangeably depending on environmental conditions.

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Purdue Extension Venison Workshops

Jonathan Ferris
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Purdue Extension Educators in Ripley and Fayette County have been conducting venison workshops for eight years. In 2004 they decided to combine efforts and conduct a series of programs across the state. Since then, the programs have become annual events each September, with a total of 17 programs that have reached 924 participants.

During each workshop, the educators discuss the proper techniques for field dressing and aging of deer; skin and quarter a deer; and proper storage and preservation methods. They cut up the meat and prepare it in a variety of ways for participants to taste. Educators also present information about proper meat handling and safety, and provide an update on current deer health issues. At the conclusion, participants have the opportunity to sample venison products prepared at the workshop and donated by local deer processors. In a survey afterwards, 98% of respondents in 2007 indicated they had learned how to make better use of the meat. Also, 99% indicated they planned to change how they handle their deer meat after attending this workshop.

Attendance data has shown that participants have come from 75 of the 92 Indiana counties, as well as from Michigan, Ohio, and Illinois. These programs have proven that they can attract new audiences to Extension, with 80% of respondents from the 2007 venison workshops indicating this was the first Extension program they had ever attended. Another positive aspect of these programs is that they cross traditional program area lines, with educators

representing 4-H and Consumer & Family Sciences as well as Agriculture & Natural Resources all involved in various capacities over the years. These programs have garnered much media attention across Indiana and the Midwest, with requests for additional programs coming in from as far away as Wisconsin and Pennsylvania.

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A Plan for Managing Chronic Wasting Disease in Wisconsin: The Next Ten Years

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After more than six years of chronic wasting disease (CWD) management in Wisconsin, it is increasingly clear that controlling CWD in Wisconsin's free-ranging white-tailed deer (*Odocoileus virginianus*) will be challenging and will require a commitment of human and financial resources over an extended period of time. The management of disease in free-ranging wildlife populations generally is difficult, expensive, and controversial, particularly when significant population reduction is a part of the plan. Control of CWD in a high density, free-ranging, white-tailed deer population is unprecedented. Yet, accepting the eventual spread of chronic wasting disease across the state as inevitable is not something the Wisconsin Department of Natural Resources (WDNR) is currently willing to do. Chronic wasting disease has the potential to negatively impact future deer hunting opportunities in Wisconsin. The WDNR has public trust responsibility for managing wildlife and ensuring the health of wildlife populations in the state, yet there is declining political and social support for the extent and duration of deer population reduction that likely would be needed to eliminate CWD. Financial limitations, societal unwillingness, and the magnitude of deer herd reductions required make the goal of eliminating CWD from Wisconsin unlikely. However, regardless of the continued challenges, continued CWD management is needed. The WDNR is therefore establishing the following goal for the management of CWD over the next 10 years: *Minimize the area of Wisconsin where CWD occurs and the number of infected deer in the state.* This goal indicates a shift in the current management approach by accepting a CWD endemic area in southern Wisconsin while concurrently focusing CWD control efforts on limiting (both spatially and in terms of local intensity) CWD to that area of the state. Our objectives are to summarize the history of CWD management in Wisconsin and to present a plan for managing CWD over the next 10 years throughout the state.

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Vegetation Response to White-tailed Deer Herbivory at Multiple Temporal and Spatial Scales in a Post-Agricultural Landscape

Michael A. Jenkins, Purdue University, West Lafayette, IN
Christopher R. Webster, Michigan Technological University, Houghton, MI
Janet H. Rock, Great Smokey Mountains National Park, TN

Intensive browsing by over-abundant white-tailed deer (*Odocoileus virginianus*) populations has altered the structure, composition, and function of many forest ecosystems. National Parks and other natural areas that prohibit hunting are often highly susceptible to these effects. In Cades Cove within Great Smoky Mountains National Park, we initiated a study that employed: (1) long-term monitoring plots, (2) a network of exclosures and controls, and (3) plant population surveys of a preferred browse species (*Trillium catesbaei*), to examine the response of vegetation to chronic herbivory at multiple spatial and temporal scales. Over a 26-year interval, monitoring plots revealed that 46 herbaceous species (mostly forest interior species) recorded on plots during the 1970s had been lost. Additionally, the herbaceous layer on these plots became significantly more homogeneous over time. Over the 10-year duration of the exclosure study, drought periodically reduced the cover of the exotic grass *Microstegium vimineum*. While seedlings within exclosures capitalized on these windows of reduced competition and advanced into the sapling layer (>50 cm tall), no tree seedling on a control plot was able to achieve and maintain a height >20 cm. Chronic herbivory has also significantly altered the demography of *T. catesbaei* populations within the Cove, yielding a highly-truncated age structure where plants flower smaller and at younger ages than in reference populations. Our results show that chronic herbivory alters vegetation at multiple scales and must be considered within the context of other disturbance and environmental factors when evaluating its long-term effects on forest ecosystems.

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The Use of Controlled Hunting to Manage Impacts of White-tailed Deer in Indiana State Parks 1993-2008

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Indiana State Parks began deer reductions in 1993 with a one-day reduction hunt at Brown County State Park. Deer reductions have continued annually since 1995 using a random drawing of public hunters and have included up to 19 parks per year. The objective of the reductions is to mitigate damage to vegetation and habitat caused by an overpopulation of white-tailed deer (*Odocoileus virginianus*) within protected state park boundaries. The decision to initiate reductions at individual parks has been based on a method of vegeta-

tion monitoring developed by Purdue University's Department of Forestry and Natural Resources. Decisions to continue reductions at individual parks are made annually using harvest data such as harvest per effort and/or harvest per square mile after each reduction. Additional consideration has recently been given to elemental occurrences and status of state rare, threatened, and endangered flora that could be affected by excessive browsing by deer at different parks. Though the program has been largely successful with dramatic changes in harvest per effort and improved floral diversity and abundance, challenges persist as we attempt to get most parks onto an every-other-year maintenance rotation of reductions (<0.20 harvest per effort). Though some parks may never achieve maintenance status given their landscape position, high percentages of hunters drawn that fail to participate, and over-selective hunting prevent higher program success.

Mike Mycroft, Natural Resource Coordinator, Illinois DNR division of State Parks & Reservoirs

The Effect of Browsing by White-tailed Deer on Forest Floor Invertebrate Communities

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The impact of browsing by deer (*Odocoileus virginianus*) on forest floor invertebrates was assessed at two park districts in northeast Ohio. At Cleveland Metroparks (CMP), a natural experiment was conducted at six reservations managed at various deer densities. At Lake Metroparks (LMP), an exclosure study was conducted using five pre-existing deer exclosures. Invertebrates were periodically sampled using pitfall traps and Berlese extraction. Data on microhabitat variables were collected to assess deer impact at each site. Analyses reveal that areas with high deer impact had fewer seedlings (P < 0.001, CMP; P < 0.001, LMP) and saplings (P =0.03, CMP; P < 0.001, LMP) compared to areas with low or no impact and had lower percent herbaceous cover (P = 0.04, CMP; P =0.009, LMP), less leaf litter biomass ($F_{1,56}$ = 6.873, P = 0.01, LMP) and lower leaf litter depth (P = 0.02, CMP; P < 0.001, LMP). At LMP, analysis of total invertebrates pooled across site and season reveled no treatment effect ($F_{1, 38}$ = 0.908, P = 0.347). However, a significant difference in community structure inside vs. outside exclosures was evident (Yates' X^2 = 56.244, df = 9, P < 0.001) based on litter dwelling invertebrates. More spiders and beetles were collected in inside vs. outside exclosures ($F_{1,28}$ = 8.165 P = 0.008). Similar results were found at CMP. We conclude that indirect impacts of deer browsing on forest floor microhabitat could have a negative impact on invertebrate communities, thus potentially affecting overall ecosystem functioning.

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How Quickly Do Forests Recover from Deer Impacts? Insights from Wisconsin Exclosure Studies

Thomas P. Rooney
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Nearly every natural-areas manager in the eastern United States is acutely aware of the impacts deer can have on biodiversity. Their counterparts in Europe, Japan, and New Zealand are wrestling with many of the same issues. Through foraging, trampling, and other activities, deer influence the structure and composition of plant communities, which in turn influences animal populations. Over the past few decades, researchers have contributed to our understanding of the nature, extent, and magnitude of deer impacts on biodiversity. Yet at the same time, deer populations have continued to grow throughout much of the eastern United States.

The deer exclosure is a venerated experimental tool for detecting and demonstrating deer impacts. By excluding deer from an area, they create an artificial, but informative, condition that is used to gauge the magnitude and extent of deer impacts. Although less appreciated, deer exclosures can also be used to determine an upper rate of recovery of vegetation following management intervention. When deer are excluded, vegetation responds in several ways: palatable or intolerant plant species often exhibit increased growth and reproduction, while non-palatable or tolerant plant species exhibit either no change or reduced growth. In this study I examine variation in vegetation recovery following deer exclusion for 3 to 18 years.

I examined plant species composition in exclosure and control plots in the northern forest region of Wisconsin, near Boulder Junction. Four exclosures were constructed in 1990 (referred to as old exclosures) in an old-growth hemlock stand and two additional exclosures were constructed in 2005 (new exclosures) in an adjacent old-growth, red pine-white pine stand. Exclosures varied in size from 196 m^2 to 720 m^2. Vegetation in old exclosures was sampled in 2006 and 2008, while vegetation in new exclosures was sampled in 2006, 2007, and 2008. I used three permanent line intercepts per exclosure, each spaced 5 m apart. Line intercepts extended 5 m into the exclosure and 5 m into control plots. Total cover of each species with leaves present below 1.5 m was identified to the nearest cm.

Total mean percent cover in old exclosures increased from 83.9% in 2006 to 89.0% in 2008, while in adjacent controls total mean percent cover increased from 22.9% to 23.5% over the same interval. Total mean percent cover in new exclosures increased from 18.3% in 2006 to 26.2% in 2008, while in adjacent controls total mean percent cover increased from 9.1% to 9.7% over the same interval. Among old exclosures, there was significant variation in total cover. In 2008, total cover in exclosures ranged from 68.1% to 103.2%. Even when deer impacts are completely excluded, other factors like light availability, soils, or initial vegetation cover will determine the vegetation recovery rate.

Vegetation inside of deer exclosures does not provide a target condition following deer reductions, but instead provides insight into the upper limit at which vegetation can recover. Exclosures also provide information about what species are able to recolonize the site following deer impact abatement. But even within a single area, the expression of recovery will be highly variable. Drawing inferences about deer impacts and deer impact abatement from a single exclosure or even a group of exclosures in a single stand could provide a misleading picture of actual vegetation recovery following deer management intervention.

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Analysis of Error in White-tailed Age Estimates Obtained by the Wear-and-Replacement Method: Age and Sex Patterns, Consequences, and Corrections

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Wildlife managers often estimate ages of harvested white-tailed deer (*Odocoileus virginianus*) and other ungulates using tooth replacement and wear. Previous studies have reported poor accuracy using this technique: however, these studies often lacked adequate sample size to examine misclassification related to sex and age. We used cementum annuli to determine the age of 857 adult (≥2.5 year old) white-tailed deer harvested in Wisconsin and Illinois. We compared cementum annuli with wear-and-replacement estimates assigned by state agency personnel. Age-classes of female deer were consistently underestimated. In contrast, misclassification of male ages was not strongly biased. We applied a simple correction method to estimate the true age structure of the deer harvest. The true age structure is considerably older than estimated by wear-and-replacement. Additionally, we found that age-class misclassification leads to biased estimates of age-specific prevalence of chronic wasting disease.

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Ratings of White-tailed Deer Preferences for Woody Browse in Indiana

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Abundant populations of white-tailed deer (*Odocoileus virginianus*) can result in levels of herbivory on woody plants sufficient to alter composition of forest communities, reduce success of afforestation and regeneration efforts, and damage landscape designs. We used a survey of forestry and wildlife professionals to test whether state-wide patterns existed in the perceived selection of white-tailed deer for native woody plant species as food. Thirty-one respondents provided ratings for 22 species of trees and 13 species of shrubs. Consistently high preference ratings were observed for oaks (*Quercus*) generally and northern red oak (*Q. rubra*) specifically. Tree species received higher preference scores, on average, than shrub species. Comparisons of responses from the northern and southern portions of the state indicated geographic differences in rankings. For six tree species, preference scores were greater in the southern portion of the state. We discuss environmental factors that could cause variation in selection by herbivores. Our ratings provide rough guidelines and increased awareness for landowners, natural resource, and landscape design professionals contemplating plantings in areas where deer are abundant. Our survey results are most appropriately viewed as working hypotheses that should form the basis of future research related to forest regeneration and plantation establishment in the presence of deer.

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Effect of Stocktype and Simulated Browse on Growth of Northern Red Oak Seedlings

Phillip Woolery and Dr. Douglass F. Jacobs
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White-tailed deer (*Odocoileus virginianus* Zimmerman) populations have grown in many parts of the country due to landscape changes and elimination of predators (Rooney 2001). In areas that have high deer population densities, browsing pressure can change forest composition and structure (Casabon and Pothier 2007). Natural and planted oak regeneration can suffer in areas with high pressures from deer browse. Because oaks are such important species for wildlife and timber, there has been a great deal of interest in regenerating oaks in the Central Hardwood Forest Region (CHFR). For seedlings to survive and compete, use of large vigorous seedlings with ability to out-compete vegetation has been recommended (Jacobs et al. 2005). In the CHFR, the majority of the seedlings produced annually are grown in bare-root nurseries (Jacobs 2003), but container grown seedlings have potential to improve hardwood reforesta-

tion. The objective of this study is to compare the survival, growth, and physiological characteristics of container and bare-root northern red oak (*Quercus rubra* L.) seedlings planted in a reforestation situation subjected to different simulated browse treatments.

The seed used for all seedlings was collected from four trees in Indiana. The bare-root seedlings were operationally grown for one year at the Indiana Department of Natural Resources State Tree Nursery near Vallonia, Indiana. The containerized seedlings were operationally grown at the University of Idaho Center for Forest Nursery and Seedling Research, where they were grown in Styroblock^{TM} containers (Beaver Plastics, Edmonton, AB) with varying cavity volumes of 170mL, 340mL, and 680mL. The clipping treatments consisted of control, dormant, and summer. The dormant browsing treatment removed the terminal buds of every stem at the time of planting. The summer browsing treatment removed 100% of all the new growth when the seedlings reach lag stage (Hanson et al. 1986).

Northern red oak seedlings were planted in a two-acre regeneration opening in April 2008 and were surrounded by an eight-foot fence to prevent deer browsing. A randomized complete block design was used with factorial treatment structure (four levels of stocktype x three levels of simulated browse treatment) with four replications (blocks). Due to the availability of stocktypes, an unbalanced design was used. Seven seedlings per treatment were used for the bare-root, 340mL and 680mL and five seedlings per treatment were used for 170mL. Seedlings and clipping treatments were randomly assigned within each block. A sample of seedlings was also destructively sampled at the time of planting.

Analysis of variance was used to detect differences between the treatments. Initially the bare-root seedlings were significantly larger, but the container seedlings had a higher root-to-shoot ratio. At the end of the first growing season, there were significant differences in stocktype ($p<0.0001$), simulated browse, ($p<0.0001$) and an interaction between stocktype and simulated browse ($p<0.0001$) for relative height growth and relative ground level diameter growth. There were no statistical differences between control and dormant clipped seedlings in all stocktypes. The summer clipped seedlings did not have any statistically significant growth. Container seedlings had higher relative height and ground level diameter growth rate compared with bare-root seedlings.

The low growth caused by summer clipping illustrates the importance of browse protection for seedlings. The likelihood that less desirable trees will overtop desired oak seedlings increases when they have been browsed. The higher growth rates for container seedlings show that these seedlings can be more competitive than bare-root seedlings. Although there were no significant differences between stocktypes within the summer clipping treatment, the container seedlings had higher relative height growth rates. Diameter growth for the largest container size, 680ml, was significantly lower than the other container sizes. This is the opposite of the accepted knowledge that larger seedlings will perform better (Jacobs et al. 2005). With further improvements in nursery cultural practices for hardwood container seedlings, these gains might be improved.

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