☞ 11hr_AC-NR_ab0099_pt04

☞

(FORM UPDATED: 08/11/2010)

WISCONSIN STATE LEGISLATURE ...
PUBLIC HEARING - COMMITTEE RECORDS

2011-12
(session year)

Assembly
(Assembly, Senate or Joint)

Committee on Natural Resources...

COMMITTEE NOTICES ...

- Committee Reports ... **CR**
- Executive Sessions ... **ES**
- Public Hearings ... **PH**

INFORMATION COLLECTED BY COMMITTEE FOR AND AGAINST PROPOSAL

- Appointments ... **Appt** (w/Record of Comm. Proceedings)
- Clearinghouse Rules ... **CRule** (w/Record of Comm. Proceedings)
- Hearing Records ... bills and resolutions (w/Record of Comm. Proceedings)
  (**ab** = Assembly Bill) (**ar** = Assembly Resolution) (**ajr** = Assembly Joint Resolution)
  (**sb** = Senate Bill) (**sr** = Senate Resolution) (**sjr** = Senate Joint Resolution)
- Miscellaneous ... **Misc**

* Contents organized for archiving by: Stefanie Rose (LRB) (August 2013)

DISCOVER HUBER NATURAL RESOURCES

May 07, 2011

MAY 13 RECD

The Honorable Jeffrey Mursau
Chair, Committee on Natural Resources
Wisconsin State Assembly
Capitol 18 North
Madison, WI 53708

RE: 2011 Assembly Bill 99; Follow-up letter to e-mail sent on 4/28/11

Dear Representative Mursau:

As a forester that has managed the same forest resource in Northeast Wisconsin for 34 years, I have grave concerns about the passage of Assembly Bill 99. The over-browsing of deer and its effect on tree seedling regeneration has been an increasing problem over recent years and I feel will lead to our northern forests no longer being sustainable. This is not only a concern of resource manages such as myself but also loggers and businesses associated with the forest products industry. I've included with this letter a legislative survey that was given at the Florence Sustainable Forestry Conference in 2010. Deer over-browsing is listed as a major concern by both loggers and business people

. The DNR has the science and ability to balance the concerns of hunters and resource managers if we let them. The passage of AS Bill 99 will not let them. You have been a strong supporter of our industry – please continue to do so by not passing Assembly Bill 99.

Thank-you,

Karen Gardner

Karen Gardner
Senior Operations Forester
Huber Resources Corp.
PO Box 352
Goodman, WI 54125
email: k.gardner@huber.com
phone # (715) 336-2290

LEGISLATIVE & AGENCY ISSUES SURVEY RESULTS

Business Owners & Economic Development results

1. Circle what profession(s) best describes you?

Business Owner—7 Economic Development—1 Entrepreneur—2
Pulp & Paper—4 Sawmill—2 Utility—2
Land Management Company—3

2. What state is your business/agency located in?

WI—13 MI—7

County WI
Florence—7
Forest—3
Langlade—1
Marinette—2
Price—1

County MI
Dickinson—2
Iron (MI) - 3
Outagamie—2

31states & 315 counties—1

3. Rank the following issues: #1 is the most significant barrier to economic success for the Forest Products Industry down to #12 being the least significant barrier.

ISSUE	RATE	ISSUE	RATE
High energy costs	4.7	Foreign competition	5.6
High fuel costs	2.4	Lack of capital for new equipment	5.9
High workers comp rates	5.4	Lack of stumpage for sale	4.9
Lack of markets for lumber/products	4.8	Higher taxes and fees	4.2
Lack of markets for pulpwood/logs	6.4	Higher insurance costs	6.4
Lack of qualified labor force	6.9		
Other:*			
Over– regulation		USDA Forest Service	
Stumpage rates			

4. Rank the following issues: #1 is the most hindering regulation down to #8 being the least hindering regulation.

ISSUE	RATE	ISSUE	RATE
Air quality regulations	5.9	Water permitting regulations	4.4
Transportation regulations	2.9	Invasive species regulations	4.9
Forest certification regulations	4.1	Biomass harvesting regulations	5.6
Low timber harvest targets- nat'l forests	1.9		
Other:*			
All of these issues are adding more cost at the logger's expense.			

* Grayed areas represent "other" ideas. Typically one vote per idea.

5. Rank the following items: #1 is the most concerning long term issue to the survival and growth of the Forest Products Industry down to #10 being the least concerning.

ISSUE	RATE	ISSUE	RATE
Shrinking workforce	5.2	Untrained workforce	6.2
Forest health issues	3.7	Smaller private land parcel sizes	4.6
Lower harvests on national forests	2.6	Competition from global suppliers	3.6
Continuing loss of railroad services	5.1	Climate change issues	7.7
Poor forest regeneration due to deer	4.8		
Other:			
Need to cut more national forests.		Remove Federal control of timberland.	
Lack of public support for forestry			

6. Rank the following items: #1 is the most serious forest health issue down to #10 being the least serious forest health issue.

ISSUE	RATE	ISSUE	RATE
Insect damage	2.6	Climate change	7.9
Drought	3.2	Lack of forest management	4.3
Deer over browsing	3.7	Competition from exotic plants	5.3
Other tree diseases	3.2	Recreational access	7.1
Soil compaction	7.0		
Other:			
Nutrient loss due to biomass production		EAB	
Government involvement			

*Grayed areas represent "other" ideas. Typically one vote per idea.

7. Which two items should your federal legislators accomplish in order to most improve the business climate for the Forest products Industry?

- Increase insect & disease R&D/funding. Find a cure or mitigation.
- Stop spending. Lower taxes
- Remove federal control of forest land.
- Bring Fed land to ASQ levels of harvest. Increase weight limits on federal Highways. Stop the BCAP program.
- More wood available from National Forest. Sensible alternate fuel (biomass) legislation.
- Incentives for start-ups of new businesses, biofuels. Less regulation that inhibit business.
- Increase harvest levels from the USFS.
- Improve their process of creating incentive programs, so as not to harm existing business to start new business.
- Timber availability from National Forest. Reduce workman's comp.
- Open fed land.
- Federal timber availability! Improved transportation issues. e.g. Haul weights, etc.

7. Which two items should your federal legislators accomplish in order to most improve the business climate for the Forest products Industry? (continued)

- Foreign competition, better forest management—Federal government. Operating cost.
- Open up National Forest to cutting and managed like it should be.
- Less regulation in transportation of forest products. Tax incentives that support small business.
- Allow federal forest to be logged for both profit and a sustainable forest.
- Open National forests to more harvesting.

8. Which two items should your state legislators accomplish in order to most improve the business climate for the Forest Products Industry?

- Promote and provide forest management including mechanisms for enhancing forestry health.
- Stop spending. Lower taxes.
- Take the national forest areas away from the federal government.
- Educate population that forestry is the best solution.
- Truck haul weights & bridge improvements. Insurance regulations.
- Renaissance zones for new business. More lower cost stumpage (state timber). At least up to annul harvest targets.
- Increase harvest volume from MI state forests to sustainable levels.
- Workman's comp issues.
- Cut taxes.
- Federal timber availability! Improved transportation issues. e.g. Haul weights, etc.
- Low interest loans for the logger. Not just the Farmer. Trucking rates, Insurance.
- Quit buying land. Taking out of the rotation of being cut. Manage deer population properly.
- Do not increase deer herd.

9. Which two items should your federal legislators accomplish in order to most improve forest health issues?

- Increase insect & disease. R&D/funding. Find a cure or mitigation.
- Stop spending. Lower taxes.
- Get federal land to ASQ level. Do not allow cap & trade.
- More wood from National Forest. Reduce fire danger, improve growth. Biomass management plan to produce/ make available low value products available from Federal lands.
- Sustainably manage/harvest more federal timber. Promote/support new industry to utilize dying timber. Beach, ash.
- Have a shorter reaction time to accomplish salvage operations. Be proactive with forest management activities.
- Aggressively manage National Forest.
- Federal timber availability! Improved transportation issues. e.g. Haul weights, etc.
- Manage the National Forest and do I care about the tree huggers?
- Micro manage federal forest. According to local circumstances.

Increase harvest targets on National forests.

10. Which two items should your state legislators accomplish in order to most improve forest health issues?

- Provide expertise and inspection at all forests, public and private.
- Stop spending. Lower taxes.
- Improve process of bidding for state/county stumpage.
- Fully staff forester position. Invasive species control.
- Sustainably manage/harvest more federal timber. Promote/support new industry to utilize dying timber. Beach, ash.
- Educate the public about good Forest Management creates healthy forest. Increase harvest levels on MI State forest.

10. Which two items should your state legislators accomplish in order to most improve forest health issues? (continued)

- Work more with the loggers. Meeting and work with the Federal to open up the National Forest.
- Raise clean water standards, for businesses. Manage deer according to local conditions—not state wide CWD.
- Federal timber availability! Improved transportation issues. e.g. Haul weights, etc.
- Do not increase deer herd in Wisconsin. Please stop giving in to pressure from hunters!

11. What can your local government do to help you accomplish your goals?

- Advise and act as a clearing house in directing or promoting forestry health (Liaison) with state and fed officials and programs.
- Stop spending. Lower taxes.
- Provide resources to help with grants for business improvement projects.
- Reduce tax.
- Support & promote new and existing wood using facilities.
- Improve truck routes. Help small business people get capital.
- Mind their own business.
- Work with the Federal to open up the National Forest.
- More incentives for good forest practices. Private & business.
- Federal timber availability! Improved transportation issues. e.g. Haul weights, etc.

LEGISLATIVE & AGENCY ISSUES SURVEY RESULTS
SUSTAINABLE FORESTRY CONFERENCE 2010
Logger & Trucker results

1. Circle what profession(s) best describes you?
   Logging—29 Trucking—2

2. What state is your business/agency located in:
   WI—10 MI—18

County WI	County MI
Florence—3	Dickinson—1
Forest—5	Iron—14
Marinette—2	Menominee—1
	Ontanagon—1

3. Rank the following issues: #1 is the most significant barrier to economic success for the Forest Products Industry down to #12 being the least significant barrier.

ISSUE	RATE	ISSUE	RATE
High energy costs	4.5	Foreign competition	6.2
High fuel costs	2.9	Lack of capital for new equipment	6.7
High workers comp rates	5.7	Lack of stumpage for sale	5.5
Lack of markets for lumber/products	4.9	Higher taxes and fees	5.1
Lack of markets for pulpwood/logs	3.4	Higher insurance costs	4.1
Lack of qualified labor force	6.2		
Other:*			
High cost of repair parts		USDA Forest Service	

4. Rank the following issues: #1 is the most hindering regulation down to #8 being the least hindering regulation.

ISSUE	RATE	ISSUE	RATE
Air quality regulations	4.9	Water permitting regulations	4.3
Transportation regulations	3.0	Invasive species regulations	3.8
Forest certification regulations	4.9	Biomass harvesting regulations	5.8
Low timber harvest targets- nat'l forests	2.8		
Other:*			
Endangered Species Act		Markets	
All of these issues are adding more cost at the logger's expense.			

* Grayed areas represent "other" ideas. Typically one vote per idea.

5. **Rank the following items: #1 is the most concerning long term issue to the survival and growth of the Forest Products Industry down to #10 being the least concerning.**

ISSUE	RATE	ISSUE	RATE
Shrinking workforce	5.1	Untrained workforce	5.7
Forest health issues	4.2	Smaller private land parcel sizes	4.6
Lower harvests on national forests	3.2	Competition from global suppliers	3.4
Continuing loss of railroad services	5	Climate change issues	6.9
Poor forest regeneration due to deer	6		
Other:			
Need to cut more national forests.		Remove Federal control of timberland.	
Markets			

6. **Rank the following items: #1 is the most serious forest health issue down to #10 being the least serious forest health issue.**

ISSUE	RATE	ISSUE	RATE
Insect damage	2.6	Climate change	6.2
Drought	3.6	Lack of forest management	4.1
Deer over browsing	5	Competition from exotic plants	6.7
Other tree diseases	3.7	Recreational access	7
Soil compaction	6.7		
Other:			
Invasive insects		Soil Fertility	
Government involvement			

* Grayed areas represent "other" ideas. Typically one vote per idea.

7. Which two items should your federal legislators accomplish in order to most improve the business climate for the Forest products Industry?

- Get rid of environmentalists.
- Timber supply. Use BCAD money to build plants that use biomass rather than subsidize loggers.
- No subsidies e.g. biomass. Financial assistance for wood utilizing facility and wood harvest and transport.
- Remove federal control of forest land.
- Fuel cost, higher insurance cost.
- Open up more US timber sales. Stop allowing endangered species b. s. Stop logging and associated industries.
- Open fed land.
- Deer! Shoot all deer! Recreation—Flatlanders Stay home!
- More stumpage on federal land.
- Foreign competition, better forest management—Federal government. Operating cost.

7. Which two items should your federal legislators accomplish in order to most improve the business climate for the Forest products Industry? (continued)

- Limit overseas trade. Impose tariffs.
- Open up National Forest to cutting and managed like it should be.
- Lower fuel rates. Put up more sales.
- Stop wood imports. Lowering fuel costs.
- Fuel/insurance costs. Develop markets, overseas competition—regulate.
- Release more Federal timer sales. Have more Federal control of insurance Costs are too high!! Feds should do something about it.
- Lower taxes, fuel costs, loss regulations . Harvest National Forest land.
- Business climate in the US is very bad. Lower taxes, less regulations (get out of the way).
- Open National forests to more harvesting.
- Less regulation. More management. Fuel Costs.
- More Government sales subsidy's.

8. Which two items should your state legislators accomplish in order to most improve the business climate for the Forest Products Industry?

- Cost down—price for product up.
- Timber supply. Level playing field by enforcing labor laws.
- Land use planning. Insurance & tax issues.
- Take the national forest areas away from the federal government.
- Fuel cost, higher insurance cost.
- Look into establishing more outlets for poor quality wood such as power plants, etc. Look at workman's comp laws.
- Cut taxes.
- National Forest. Rail Road.
- Tax breaks for the forest industry. Less regulation on trucking.
- Pass laws to help not hinder loggers to get wood products from the stump to the mill. Low interest loans for the logger. Not just the Farmer. Trucking rates, Insurance.
- Use railroads for shipment. Lowering fuel costs.
- More state sales & subsidize fuel, etc.
- Regulate costs, insurance & fuels.
- Make state timber sales more affordable to the smaller loggers. Make sales more appealing to small loggers, not just favoring larger loggers firms.
- Lower business taxes, less regulations.
- Get rid of single business tax in MI.
- Address the weighted timber or USDA lands.

9. Which two items should your federal legislators accomplish in order to most improve forest health issues?

- Get rid of the beetles
- Cut more fed wood.
- Dollars for research. Demand better utilization of forest products.
- Competition from global suppliers. Smaller private land parcel sizes.
- Find ways to kill or stop invasive species from attacking our forests. Stop listening to the anti's unless you want to totally ruin our forest industry.
- Water, bugs.
- Inact a much more aggressive harvest program on the National Forest Lands.
- Manage the National Forest and do I care about the tree huggers?

9. Which two items should your federal legislators accomplish in order to most improve forest health issues? (continued)

- Get rid of diseased trees. More plantations.
- Don't worry about plants for deer.
- Disease control.
- Open up more state/Fed land to logging.
- Do studies on soil fertility before & after harvesting. Encourage more studies on utilizing poor sites for replanting.
- Less regulations, open National forest land for harvesting.
- Don't regulate it. Manage it.

Address the mismanagement of Federal Forest and the waste in the resource.

10. Which two items should your state legislators accomplish in order to most improve forest health issues?

- Give private landowners more incentive to cut timber. "tax credits"
- Encourage more active management of forest. More dollars for research and coop extension.
- Competition from global suppliers. Smaller private land parcel sizes.
- Have research funds available to combat invasive species or on immediate notice. Have a system to rate landowner & loggers so the public know who is who.
- New president of the United States of America.
- Inact a much more aggressive harvest program on the State/DNR/County lands.
- Work more with the loggers. Meeting and work with the Federal to open up the National Forest.
- Get rid of diseased trees. More plantations.
- Don't worry about plants or deer.
- Disease control . Programs for private landowners.
- Totally prohibit the use of tree length logging, in Northern Hardwood stands. Encourage more manual means of harvesting.
- Less regulations, cut more state sales. Let us do our job.
- Fuel.

11. What can your local government do to help you accomplish your goals?

- Start listening to the people they work for.
- Weight laws on township roads. Understand importance of forest to local community.
- Cut fuel cost. Make an environment friendly system that a logger or landowner can feel comfortable to access and present problems with answers available. Mind their own business.
- Work with us.
- Work with loggers on weight limits on town roads.
- Work with the Federal to open up the National Forest.
- Get rid of diseased trees. More plantations.
- Set up sales instead of letting trees die.
- Work closer with private landowners on access issues.
- Lift the load restrictions when they can be so that loggers ca be back to work and can do their part in the economics of the area.
- Reduce taxes, less regulations. Let us do our job.
- Better road management. More jobs.


FORWARD
E PLURIBUS UNUM

Please turn off volumes of all personal electronic devices

Today's hearing will be covered by Wisconsin Eye. Members of the committee and witnesses are reminded to press the red microphone buttons to turn on their microphones so all of Wisconsin can hear us.

Hearing witness slips on tables in the hallway and need to be filled out in order to testify or register on the bill.

Hand to the Sergeant at Arms Staff who will hand them to the Committee Clerk
If timing is an issue for you, please make a note on your hearing witness slip

If you have written testimony you want to share with the committee, please hand it to the sergeant's staff and they will distribute it to members of the committee

5 minutes testimony will be allowed to the main proponents, opponents and DNR
3 minuets testimony will be allowed to all other speakers

Today we are hearing testimony on Assembly Bill 99 regarding deer hunting.

However, we are first conducting an executive session on:

Assembly Bill 23, regarding continuous disinfection of water;
Assembly Bill 48, regarding a directory of stewardship funded properties; and
Assembly Bill 73, regarding the registration of piers

We are now entering executive session, the clerk will call the roll


FORWARD
E PLURIBUS UNUM

The Nature Conservancy
Protecting nature. Preserving life.™

The Nature Conservancy in Wisconsin
633 West Main Street
Madison, Wisconsin 53703

tel 608/251-8140
fax 608/251-8535
nature.org/wisconsin

Representative Jeffrey Mursau
P.O. Box 8953
Madison, WI 53708

Dear Chairman Mursau and Committee Members:

The Nature Conservancy would like to take this opportunity to raise our concerns regarding Assembly Bill 99. Our organization's interest in this issue is the profound impact that white-tailed deer have on the sustainability and biodiversity of our forests. The Legislature and the Department of Natural Resources with its wildlife management professionals have always had a difficult task in balancing wide range of constituencies that are affected by deer population, and we appreciate your attention to this important issue.

The Conservancy supports the DNR's continued effort to use the best science they have available to meet deer population goals. Our organization believes that it is essential that the population goals and techniques used take full account of the impact that deer density has on forest's sustainability and biodiversity. Deer herbivory continues to be one of the greatest challenges to the economic, ecological and social values of our forests in Wisconsin. Scientific studies have shown clearly that abundant deer populations have long term negative impacts on the regeneration, quality, and biodiversity of Wisconsin's forests. These impacts result in forests that are much more vulnerable to invasive species and droughts.

We believe that it is critical that the DNR has all the tools necessary to meet its population goals in all areas of the state. These tools including the use of earn a buck and establishment of fall open seasons for hunting deer with firearms. For that reason we encourage you to not move forward with Assembly Bill 99, but to continue to work with hunters, farmers and foresters to develop deer management goals and techniques that can meet all of our goals.

We strongly advocate that the Legislature and DNR make their decisions on deer management based on the best science available and recognize the impact these decisions have on the ecological, economical, and social values of our forests.

Sincerely,

Casey Eggleston
Government Relations Coordinator
The Nature Conservancy – Wisconsin Chapter


FORWARD
E PLURIBUS UNUM

Wisconsin Woodland Owners Association, Inc.

P.O. Box 285, Stevens Point, WI 54481-0285

www.wisconsinwoodlands.org

LRB – 1821/1

The Wisconsin Woodland Owners Association is in support of the Wisconsin Wildlife Federation's position regarding LRB 1821/1, recommending to not pass this bill until you have had an opportunity to hear from conservationists, farmers and those engaged in forestry in this state.

WWOA values the opinion of the Wisconsin deer hunters, and is aware of the economics that go hand in hand with a healthy deer population and successful hunting. Deer hunting has a strong tradition in Wisconsin and healthy forest and a healthy deer herd is essential for continued success and enjoyment.

WWOA has previously stated and maintains a position of a scientific approach for control and management of Wisconsin' deer herd. Deer populations in Wisconsin are very dynamic and can swing from low populations to excessive populations in just a few years in certain areas. There are over 120 deer hunting units in Wisconsin and changes in land ownership and management have made dramatic changes to hunting patterns and herd control options. A scientific approach would refer to forest types and their herd capacity capabilities. This structure varies greatly throughout the state.

WWOA does not specifically support Earn-a-Buck or the special October hunts, but feels that the options not be permanently removed as a possible management tool if needed.

In conclusion, WWOA is urging you to not support LRB 1821/1, but to continue to provide strong oversight of DNR rulemaking to assure that we maintain healthy forests, which in turn will provide hunting opportunities for now and future generations.

Loren Hanson

Loren Hanson

President, Wisconsin Woodland Owners Association


FORWARD
E PLURIBUS UNUM

From Jeff Gerlach

IMPACTS OF WHITE-TAILED DEER ON FOREST REGENERATION IN NORTHWESTERN PENNSYLVANIA

NANCY G. TILGHMAN,[1] U.S. Forest Service, Northeastern Forest Experiment Station, Box 928, Warren, PA 16365

Abstract: Browsing by white-tailed deer (*Odocoileus virginianus*) is a major cause of regeneration failure in Allegheny hardwood forests of northwestern Pennsylvania. I examined the impact of deer at 5 different densities (0, 10, 20, 40, and 80 deer/259 ha) on tree seedlings, woody shrubs, and herbaceous plants in large enclosures over 5 years. I examined 3 silvicultural treatments (clearcut, thinning, and uncut) at each density. After 5 years, tree seedlings in the clearcuts at the lowest deer densities were nearly twice as tall as those at the highest deer densities. Browsing at high deer densities also reduced the diversity of tree seedlings, resulting in nearly pure black cherry (*Prunus serotina*) regeneration. Fern cover increased with increasing deer densities and blackberry cover (*Rubus* spp.) decreased. I suggest deer populations should be maintained at ≤18 deer/259 ha to ensure tree regeneration and desired tree species composition.

J. WILDL. MANAGE. 53(3):524–532

Dense white-tailed deer populations in forested regions can alter forest stand development and reduce wildlife habitat by reducing or eliminating young tree seedlings, shrubs, and herbaceous plants (Tierson et al. 1966, Jordan 1967, Marquis 1981*a*). Since 1930 in the Allegheny hardwood forests of northwestern and north-central Pennsylvania, deer densities have been high (Frontz 1930, Bramble and English 1948), but the role deer play in forest regeneration in Allegheny hardwood forests has been demonstrated only recently (Bennett 1957, Marquis 1981*a*, Marquis and Brenneman 1981).

Allegheny hardwood forests are essentially even-aged, resulting from widespread clearcutting that occurred from about 1890 to 1930 (Marquis 1975). Many stands are approaching maturity, but forest landowners hesitate to harvest them because they will not regenerate to desired species without a monetary investment. Guidelines based on surveys of overstory and understory conditions have been developed to help determine which silvicultural options (e.g., type of harvest cut and need for investments in fencing, herbiciding, and fertilizing) are necessary in these stands (Marquis et al. 1984). One of the major factors that enters in the decision process is density of deer populations. My objective was to determine the maximum deer population that will allow natural regeneration of Allegheny hardwood forests. Specifically, I was interested in differences in stocking, plant species composition, or height growth of new stems as deer densities increased. I also looked for changes in ground cover by herbaceous plants, especially those species that interfere with the development of Allegheny hardwood regeneration (Horsley 1977, Horsley and Marquis 1983).

I thank H. S. Steele, V. L. Flick, J. C. Redding, J. A. Crossley, V. D. Brown, and D. L. Saf for field assistance. Many people reivewed this manuscript and I thank them all for their input, but I give special thanks to D. A. Marquis, K. R. McCaffery, P. R. Krausman, and 1 anonymous reviewer for their detailed comments and suggestions on the manuscript. The Allegheny National Forest, Pennsylvania Game Commission, Pennsylvania Bureau of Forestry and National Fuel Gas Company assisted by providing funds, land for the enclosure locations, and help with fence construction. This study was funded and administered by the U.S. Forest Service, Northeastern Forest Experiment Station.

STUDY AREAS

I located 4 study sites on the Allegheny Plateau in northwestern and north-central Pennsylvania at elevations ranging from 550 to 700 m. All were in 60–70-year-old Allegheny hardwood stands dominated by black cherry, red maple (*Acer rubrum*), and sugar maple (*A. saccharum*). Two sites (Fool's Creek and Deadman Corners) were located on the Allegheny National Forest, 1 on State Game Land 30, and 1 (Wildwood Tower) on Elk State Forest and land belonging to the National Fuel Gas Company (Fig. 1).

Sites were established in stands with similar

[1] Present address: U.S. Forest Service, P.O. Box 96090, Washington, DC 20090-6090. Submit reprint requests to: David A. Marquis, Forestry Sciences Laboratory, P.O. Box 928, Warren, PA 16365.

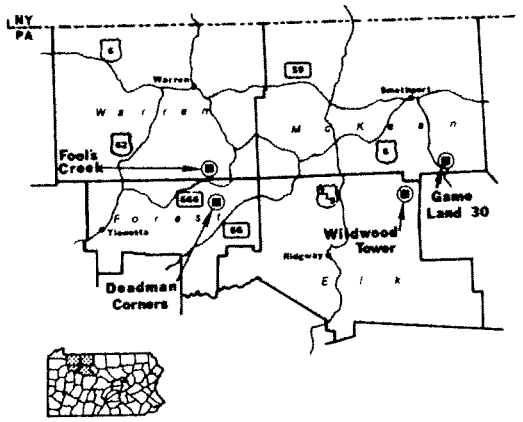

Fig. 1. Location of study areas in northwestern Pennsylvania.

overstories, but with understories of tree seedlings that represented different potentials to regenerate after clearcutting. The 4 sites represented the range in understory conditions on the Allegheny Plateau. The Deadman Corners site was well stocked with advance regeneration (Table 1) and was predicted to regenerate successfully after clearcutting even at fairly high deer populations (Marquis et al. 1984). The Fool's Creek site had less advance regeneration (Table 1) and an intermediate potential to regenerate after harvest cutting. The other 2 study sites had less advance regeneration, more interfering plants such as ferns, grasses, striped maple (*Acer pensylvanicum*), or American beech (*Fagus grandifolia*), and were not predicted to regenerate successfully after clearcutting, especially with high deer densities (Table 1).

METHODS

At each site, a 65-ha enclosure was constructed of 2.4-m woven wire fencing and subdivided into 4 subenclosures: 1 26 ha and 3 13 ha (Fig. 2). Two of these enclosures were completed in 1979 and 2 in 1980. Captive-raised yearling white-tailed females were used to stock the enclosures with 1 deer in the 26-ha pen and 1, 2, and 4 deer in each of the 13-ha pens to simulate 10, 20, 40, and 80 deer/259 ha, respectively. Five fenced plots (radius = 4.5 m) were randomly located in each cutting treatment in all 4 deer densities to represent the no-deer treatment. Each deer was equipped with a radio transmitter with a mortality switch to aid in relocation and verification of deer densities. Each subenclosure was treated with 3 different cutting treatments: 10% was clearcut, 30% was thinned (to 60% residual relative density), and the rest was left uncut. This cutting scheme was selected to simulate the relative amount of cutting that would take place every 10 years on an intensively managed forest.

Each enclosure was visited biweekly to maintain the fences and to verify the deer densities. When dead deer were found, bone marrows were checked to determine nutritional status (Cheatum 1949). When deer died or escaped, I replaced them to maintain densities. The only exception was when deer died in the winter; they were not replaced until after vegetation green-up in the spring. In the early years of this study, we found that deer placed in these areas in midwinter did not survive. Actual deer densities were calculated for each calendar year based on the number of deer-days for each enclosure (Table 2).

Systematically spaced 0.004-ha (radius = 1.1 m) vegetation sample plots were established throughout each subenclosure, with 25 in the clearcut, 15 in the thinning, and 20 in the uncut portion. Sampling intensity was greatest in the clearcuts because successful regeneration of Allegheny hardwood stands was the primary study

Table 1. Percent of 0.004-ha vegetation plots at each of 4 study sites meeting certain understory criteria prior to installation of enclosures, northwestern Pennsylvania, 1979.

Criteria	Deadman Corners	Fool's Creek	Wildwood Tower	Game Land 30
>25 black cherry seedlings[a]	94	55	28	16
>100 desirable seedlings[a]	80	29	5	7
>30% grass or fern cover[b]	12	8	17	54
>8 stems of beech or striped maple[b]	14	11	60	43

[a] Advance regeneration is adequate if ≥70% of the vegetation plots in a stand are stocked with >25 black cherry seedlings or >100 desirable seedlings (Marquis et al. 1984). In this region, desirable species of tree seedlings for timber production include black cherry, sugar maple, red maple, white ash, yellow-poplar, cucumbertree, and northern red oak.

[b] These understory plants may interfere with natural regeneration of a stand if ≥70% of the sample plots are stocked with these amounts of potentially interfering plants in a proposed clearcut or if ≥30% of the plots are stocked with these plants in a proposed shelterwood cut (Marquis et al. 1984).

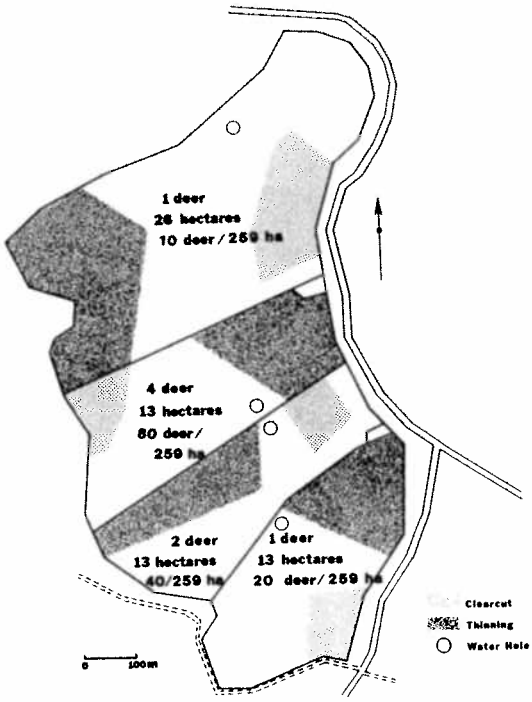

Fig. 2. Example of enclosure layout for deer density experiments, northwestern Pennsylvania, 1979–84.

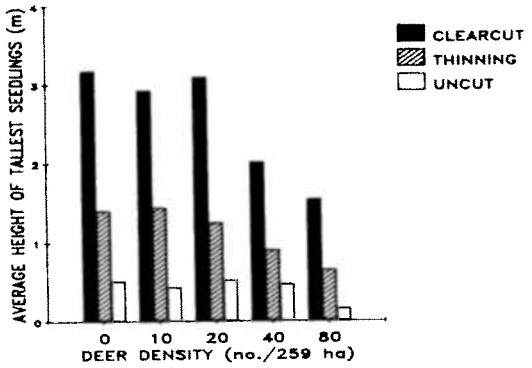

Fig. 3. Mean height (m) of dominant tree seedlings growing in clearcut, thinned, and uncut Allegheny hardwood stands in northwestern Pennsylvania and subjected to 5 different deer densities, 1979–84.

objective. Vegetation was measured in late summer prior to deer stocking, and thereafter at years 3 and 5. Tree seedlings were tallied by species and height class, and the height of the tallest seedlings of black cherry, sugar maple, red maple, white ash (*Fraxinus americana*), other desirable (yellow-poplar [*Liriodendron tulipifera*], cucumbertree [*Magnolia acuminata*], and northern red oak [*Quercus rubra*]), and other commercial timber species (American beech, yellow birch [*Betula alleghaniensis*], sweet birch [*B. lenta*], eastern hemlock [*Tsuga canadensis*], bigtooth aspen [*Populus grandidentata*], and quaking aspen [*P. tremuloides*])

Table 2. Estimated deer density in each subenclosure at each study site in northwestern Pennsylvania during the first 5 growing seasons after introduction of deer (Deadman Corners and Fool's Creek = 1979–83; Wildwood Tower and Game Land 30 = 1980–84).

Target density/259 ha	Deadman Corners	Fool's Creek	Wildwood Tower	Game Land 30
10	9.4	9.2	10.1	10.2
20	21.2	18.8	20.2	19.9
40	40.6	36.6	36.2	40.3
80	72.5	70.0	66.7	68.5

were recorded. The height of the tallest stem of commercial or noncommercial species was recorded for each plot (also referred to as dominant). Percent ground cover was estimated for each of the herbaceous plant species on each plot.

Effects of the various deer densities and cutting treatments were examined by analysis of variance with a split-plot design. Deer densities constituted the main plots and cutting treatments the subplots, with sites as blocks. Duncan's multiple-range test was used to separate significant means. Sigfiicance was established when $P \leq 0.05$.

RESULTS

Differences Due to Deer Density

After 5 years there were differences in the height growth, density, and species composition of regeneration. There were marked differences in the ground cover for certain herbaceous species. Differences in the vegetation of the various deer densities were greatest in the clearcuts where rapid seedling growth occurred and least in the uncut areas where seedling development was slow because of low light intensity.

The most obvious difference was in the mean height of the tallest woody stems on the sample plots (Fig. 3). These stems were stump sprouts or seedlings of any tree species, commercial or noncommercial. In the clearcuts with lowest deer density, the mean height of these tallest stems was about 3 m; approximately 5% of these stems were stump sprouts. In the clearcuts with highest deer density, the tallest stems were almost entirely of seedling origin and were significantly

Table 3. Mean density of tree seedlings (×1,000/ha) by browsing sensitivity, commercial value, and height class in clearcuts of different deer densities, northwestern Pennsylvania, 1979–84.

Sensitivity[a]—Value Ht class	Deer density/259 ha				
	0	10	20	40	80
Sensitive—Commercial[b]					
Total	37.1	33.4	33.9	29.9	84.0[c]
>0.9 m	4.0	4.9	4.0	2.5	0.1
>1.5 m	3.0A[d]	2.0AB	1.7AB	1.0BC	0C
Sensitive—Noncommercial[e]					
Total	29.4A	20.3A	25.7A	2.7B	3.2B
>0.9 m	26.4A	19.0A	23.5A	2.0B	1.2B
>1.5 m	20.3A	14.6A	19.3A	1.5B	0.7B
Less sensitive—Commercial[f]					
Total	70.4	63.0	52.6	82.8	88.2
>0.9 m	21.5	26.7	19.5	30.6	20.8
>1.5 m	8.9	14.3	8.6	13.3	8.9
Less sensitive—Noncommercial[g]					
Total	3.0	6.2	3.2	4.9	2.2
>0.9 m	1.2	3.7	1.2	2.0	0.7
>1.5 m	0.7	2.2	0.5	1.0	0.1

[a] Tree species were designated as sensitive or less sensitive to browsing based on studies of deer browsing in Allegheny hardwood stands (Marquis 1981*a*, 1983; Marquis and Brenneman 1981).
[b] Sugar maple, red maple, white ash, yellow birch, and sweet birch.
[c] Includes an abundance of tiny birch seedlings in 1 pen that germinated after good seed production.
[d] Means within rows followed by different capital letters were different ($P < 0.05$).
[e] Pin cherry.
[f] Black cherry and American beech.
[g] Striped maple.

shorter ($\bar{x}$ = 1.6 m, $F = 14.32$, $P = 0.00016$). In the clearcuts with highest deer density, sprouts and seedlings were eliminated except where protected by slash. In the thinned areas, the tallest stems in the lowest deer densities were twice as tall as those in the highest deer densities ($F = 3.28$, $P = 0.049$) (Fig. 3).

Important differences also occurred in seedling numbers. Many seedlings became established in all treatments, and deer density had little effect on the total numbers established. But the number of seedlings that developed into the larger size classes was strongly affected by deer density, especially for those species more sensitive to browsing in the cutting treatments that permitted rapid seedling growth.

In the clearcuts (Table 3), the number of stems of noncommercial species sensitive to browsing, such as pin cherry, were significantly ($P = 0.008$) and dramatically reduced at the 2 highest deer densities. Likewise, the number of stems of commercial species sensitive to browsing, such as sugar maple, red maple, white ash, and birch, in the >1.5 m tall size class were significantly reduced at high deer densities ($P = 0.036$); a similar trend occurred in the >0.9 m size class for these species ($P = 0.076$).

In the thinnings, similar trends were evident, although the differences were not statistically significant (Table 4). Nevertheless, there were substantially fewer seedlings of browse-sensitive species in the larger size classes at very high deer densities. There were no significant differences in seedling numbers in the uncut portions of the enclosures (Table 5).

Species composition of tree regeneration was significantly different between the high and low deer densities. There were fewer tree seedling species in the high deer-density treatments than in any of the other densities. These differences are best demonstrated for the larger height classes, which varied among the different cutting treatments (Fig. 4). In the clearcuts, species diversity of seedlings >1.5 m tall was significantly reduced in the highest density pen ($P = 0.0017$). Only 2 species, usually black cherry and striped maple, escaped deer browsing to grow into this height class at these deer densities. Occasionally, stems of 1 of the more browse-sensitive species grew out of the reach of deer (>1.5 m) in the clearcuts, but such seedlings were surrounded by logging slash and thus were protected from browsing. In the thinnings, species diversities of seedlings >0.9 m at the 2 highest

Table 4. Mean density of tree seedlings (×1,000/ha) by browsing sensitivity, commercial value, and height class in thinnings of different deer densities, northwestern Pennsylvania, 1979–84.

Sensitivity[a]—Value / Ht class	Deer density/259 ha 0	10	20	40	80
Sensitive—Commercial[b]					
Total	51.1	40.8	33.1	86.4	29.7
>0.3 m	5.4	7.9	8.0	8.7	2.9
>0.9 m	1.5	1.3	2.0	1.0	0
Sensitive—Noncommercial[c]					
Total	1.2	1.0	0.7	1.0	1.7
>0.3 m	0.5	0.2	0	0.2	0.2
>0.9 m	1.7	2.2	1.2	0.1	1.5
Less sensitive—Commercial[d]					
Total	146.5	164.6	183.4	200.4	201.4
>0.3 m	19.8	16.3	11.6	18.3	44.7
>0.9 m	1.2	2.7	1.2	0.4	1.5
Less sensitive—Noncommercial[e]					
Total	7.9	11.9	8.9	8.6	8.9
>0.3 m	6.4	8.9	7.2	5.9	6.4
>0.9 m	4.0	4.2	3.2	1.5	1.5

[a] Tree species were designated as sensitive or less sensitive to browsing based on studies of deer browsing in Allegheny hardwood stands (Marquis 1981*a*, 1983; Marquis and Brenneman 1981).
[b] Sugar maple, red maple, white ash, yellow birch, and sweet birch.
[c] Pin cherry.
[d] Black cherry and American beech.
[e] Striped maple.

Table 5. Mean density of tree seedlings (×1,000/ha) by browsing sensitivity, commercial value, and height class in uncut areas of different deer densities, northwestern Pennsylvania, 1979–84.

Sensitivity[a]—Value / Ht class	Deer density/259 ha 0	10	20	40	80
Sensitive—Commercial[b]					
Total	34.1	22.6	39.3	25.4	10.4
>0.3 m	0.8	0.2	1.2	1.5	0
>0.9 m	0	0.1	0	0	0
Sensitive—Noncommercial[c]					
Total	0.2	0.1	0.2	0.2	0
>0.3 m	0	0	0	0	0
>0.9 m	0	0	0	0	0
Less sensitive—Commercial[d]					
Total	135.7	97.1	104.0	74.1	69.7
>0.3 m	8.9	2.5	3.2	2.2	0.6
>0.9 m	0.2	0.1	0	0.2	0
Less sensitive—Noncommercial[e]					
Total	10.9	10.4	14.1	10.1	3.7
>0.3 m	5.9	3.7	5.2	4.7	0.5
>0.9 m	0.7	0.5	0.5	0.5	0

[a] Tree species were designated as sensitive or less sensitive to browsing based on studies of deer browsing in Allegheny hardwood stands (Marquis 1981*a*, 1983; Marquis and Brenneman 1981).
[b] Sugar maple, red maple, white ash, yellow birch, and sweet birch.
[c] Pin cherry.
[d] Black cherry and American beech.
[e] Striped maple.

deer densities were significantly less than at the lowest deer density ($P = 0.0001$). In the uncut areas, the number of tree seedling species >0.3 m tall in the highest deer density was reduced to a single species ($P = 0.052$).

The increased dominance of black cherry in the new growth at the higher deer densities was most apparent in the clearcuts. In the clearcuts with highest deer density, 75% of the sample plots were dominated by black cherry whereas only 18% of the sample plots without deer were dominated by this species ($P = 0.0005$) (Fig. 5).

Ground cover of various herbaceous plants changed as deer density increased (Fig. 6). Blackberry cover in the highest deer-density clearcuts was significantly less than in any of the other deer densities ($P = 0.019$). A similar decrease in blackberries also was apparent in the high deer-density thinnings ($\bar{x} = 38\%$ cover in thinnings of the 10 deer/259 ha treatments vs. 3.5% cover in the 80 deer/259 ha treatments) ($P = 0.0014$). Hay-scented fern (*Dennstaedtia punctilobula*) and New York fern (*Thelypteris noveboracensis*) increased in the clearcuts with high deer density ($P = 0.0009$) (Fig. 6).

In addition to these common herbaceous species, 45 other herbaceous plants were found on the sample plots. The mean percent cover by each of these species was generally small (<1% for most species) and therefore significant differences in cover among the different deer densities were not detectable.

Winter Mortality of Deer

From 1980 to 1985, 57% of the deer in the 80 deer/259 ha treatments died during the winter from starvation and exposure; 33% of the deer in the 40 deer/259 ha treatments died during these winters. Only 1 deer in the 20 deer/259 ha treatment died of starvation and none died in the lowest deer density. Most of these deaths occurred in February and March when the deer had used up their winter fat reserves and new woody growth was not available.

These mortality figures are heavily influenced by the study design, which artificially forced the deer to stay on the plateau top throughout the winter. Thus, study deer were exposed to far more extreme conditions than free-ranging deer that seek out sheltered lower slopes and conifer stands during harsh winter weather.

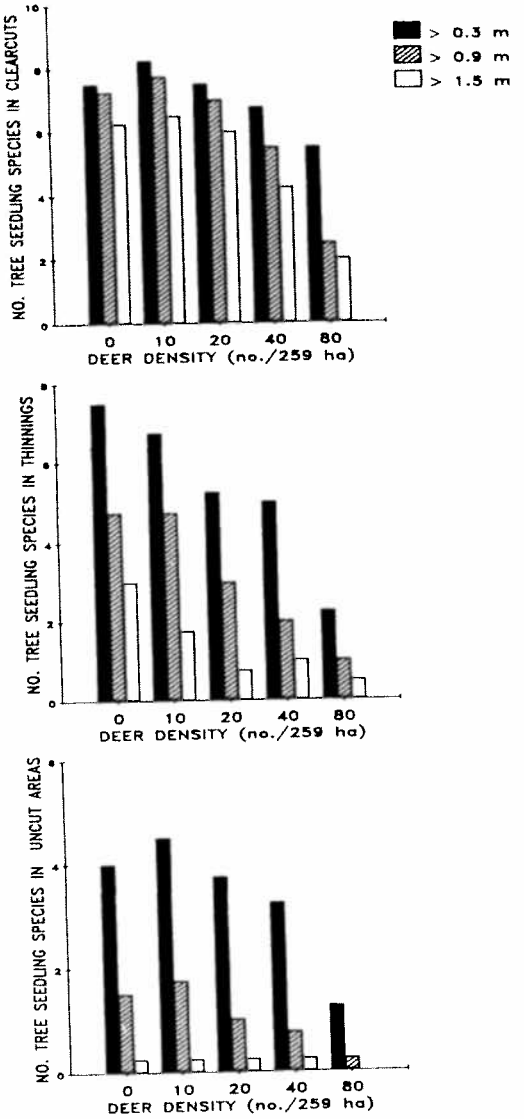

Fig. 4. Species diversity of 3 size classes of tree seedlings growing in clearcut, thinned, and uncut Allegheny hardwood stands in northwestern Pennsylvania and subjected to 5 different deer densities, 1979–84.

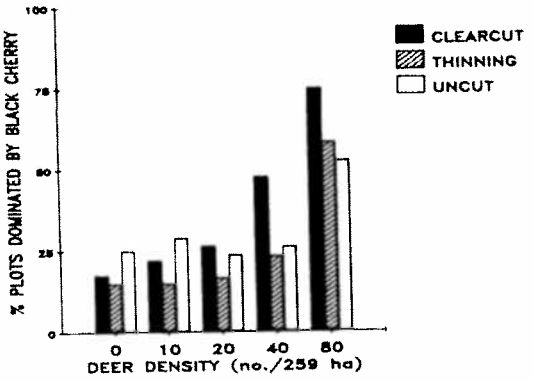

Fig. 5. Black cherry dominance among tree seedlings growing in clearcut, thinned, and uncut Allegheny hardwood stands in northwestern Pennsylvania and subjected to 5 different deer densities, 1979–84.

Thus, I do not consider these mortality rates to be representative of the mortality that might occur among free-ranging deer at the same densities.

DISCUSSION

The results of this study demonstrate that high densities of white-tailed deer (40 and 80 deer/259 ha treatments) have a detrimental impact on species composition and development of regeneration in thinned and clearcut stands. In uncut stands, the impact of deer browsing was evident only in the 80 deer/259 ha treatment. Loss of seedling height growth at these high deer densities confirms findings reported from numerous exclosure studies (Curtis and Rushmore 1958; Graham 1958; Farnsworth and Barrett 1966; Tierson et al. 1966; Jordan 1967; Marquis 1974, 1981*a*; Marquis and Grisez 1978). Marquis (1981*a*) estimated that delays in establishment of new stands and reduced stocking levels in the heavily browsed Allegheny hardwood stands of northwestern Pennsylvania cost forest landowners about $2,656/ha or $33/ha/year, a reduction in yield of about 50%.

To make it easier to see the impact of deer in changing plant species composition, I grouped species into 2 groups: those sensitive to browsing, and those that were not. Those species most sensitive to browsing in northwestern Pennsylvania (e.g., pin cherry, sugar maple, white ash, yellow birch, and yellow-poplar) (Marquis 1983) disappeared as the deer density increased, whereas less sensitive species such as black cherry, striped maple, and American beech survived. In some Allegheny hardwood stands, dense striped maple and beech understories have prevented the establishment of more desirable tree seedling species (Horsley 1983). Black cherry ranks somewhere in the middle of the range of tree species' sensitivity to browsing (Marquis 1983), but because black cherry grows rapidly in full sunlight, many of the seedlings were able to survive under intense browsing pressure.

The nearly pure stands of black cherry that resulted from intense deer browsing are not altogether desirable even though cherry is a prime

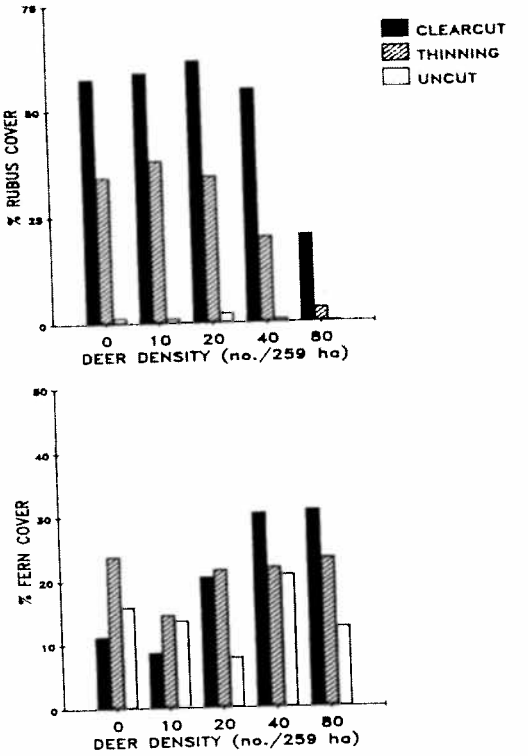

Fig. 6. Herbaceous ground cover in clearcut, thinned, and uncut Allegheny hardwood stands in northwestern Pennsylvania. These stands were subjected to 5 different deer densities, 1979–84.

timber species. A reduction in tree species diversity would severely affect local industries that use species other than black cherry (e.g., white ash for baseball bats and tool handles, red and sugar maple for furniture). Also, if vast areas of pure black cherry stands were to develop throughout this region, the potential threat from an outbreak of an insect or disease epidemic would be great. There is some concern that insects like the cherry scallop-shell moth (*Hydria prunivorata*), which periodically defoliates black cherry trees, could become a major cause of mortality.

The shift to near-monocultures of black cherry in areas of high deer populations also would affect wildlife habitat. A decrease in the diversity of overstory trees would result in a decrease in the diversity of wildlife foods available (fruits, seeds, browse, and insects). White-tailed deer have trouble surviving the rigors of winter when fed a diet of a single species (Dahlberg and Guettinger 1956:76, Banasiak 1961), so a cherry monoculture could eventually lead to poor deer nutrition even in areas of cherry seedling abundance. Black cherry, as opposed to sugar maple, does not readily decay or form natural cavities (Rexrode and Auchmoody 1982), and is rarely used by primary and secondary cavity-nesters (Carey 1983).

The changes in herbaceous cover also affect the regeneration potentials of these stands. Low deer-density areas generally had little fern cover in the clearcuts and an abundance of blackberries in clearcuts and thinnings, whereas the high deer-density areas had scattered patches of dense fern cover and few blackberries. Horsley and Marquis (1983) demonstrated that seedlings grown in the presence of ferns had significantly lower survival and growth rates than seedlings grown without ferns. Previous studies (Marquis and Grisez 1978, Horsley and Marquis 1983) have also shown that blackberries interfere with ferns and can lead to a decline in their coverage. Deer not only have a direct effect on forest regeneration by browsing on seedlings, but also can indirectly affect the development of regeneration by changing the composition of the herbaceous vegetation, which, in turn, affects the growth and survival of seedlings.

MANAGEMENT IMPLICATIONS

Deer density has a major impact on tree regeneration and herbaceous plant cover in Allegheny hardwood forests. Deer densities of 40 and 80 deer/259 ha will result in a delay in tree regeneration and a reduction in tree species diversity. The maximum year-round deer density permitting desirable tree regeneration in this forested region of Pennsylvania is around 30 deer/259 ha (range = 20–40 deer/259 ha).

However, 30 deer/259 ha cannot be assumed as a carrying capacity in establishing deer management goals in this part of Pennsylvania for several reasons. First, population estimates used by the Pennsylvania Game Commission in their deer management efforts are overwinter values, whereas those used in this study were year-round values. Secondly, the Commission's population estimates are based on county-wide estimates from change-in-ratio procedures (Shope 1978), and are not directly comparable to the actual deer numbers of this experiment. Finally, the Commission estimates of carrying capacity are based on surveys of actual forest conditions in each county, whereas this study provides estimates for a forest managed at theoretically ideal cutting levels.

Assuming that 30 deer/259 ha under conditions of this experiment represents the maximum population that will produce fully satisfactory tree regeneration, I have applied a series of adjustments to this value to yield a deer population goal that would be comparable to current deer management figures for this region of Pennsylvania and consistent with the typical forest management practices in the region, rather than the ideal ones used in this experiment.

Because mean year-round deer populations are always higher than their corresponding overwinter populations, I adjusted the 30 deer/259 ha figure, using Pennsylvania Game Commission data for the 4-county area of the study that shows summer (post-breeding) populations range from 1.2 to 1.6 × ($\bar{x} = 1.4$) the overwinter densities (W. K. Shope, Pa. Game Comm., unpubl. data). Because each season represents approximately half the year, year-round densities can be expected to be 1.2 × higher than overwinter densities. Thus, 30 deer/259 ha year-round is equivalent to an overwinter density of 25 deer/259 ha.

The next adjustment was intended to bring the study estimate of overwinter carrying capacity (25 deer/259 ha) into line with the reduced amount of deer food available under usual management conditions, where there is only about half as much clearcutting and thinning as in the experiment. Data developed by Marquis (1981*b*) were used to calculate deer food production in Allegheny hardwood forests that had 10% clearcutting and 30% thinning (as in the study enclosures), or 5% clearcutting and 15% thinning every 10 years (a more realistic pattern outside). These calculations indicated the present level of cutting outside would produce 21% less browse than the cutting level used in this study. Thus the carrying capacity estimate was further reduced by 21% to 20 deer/259 ha.

The final adjustment for differences between the change-in-ratio estimates of deer density and actual deer numbers in the study was based upon a pellet-group survey conducted in the spring of 1986. Pellet groups were counted along 8 km of line-transects in a watershed immediately adjacent to 1 study enclosure to yield a deer-density estimate for the period from mid-October to April. These line-transect estimates were calibrated by conducting similar counts inside the enclosure in areas where the overwinter deer densities were known. We found that the county-wide change-in-ratio estimate was about 22% lower than the estimate from the pellet-group procedure. So, the overwinter deer-density value was reduced by 22% (from 20 deer/259 ha to 15 deer/259 ha) to make study density values comparable to the Pennsylvania Game Commission figures.

This estimate is slightly lower than the 18 deer/259 ha goal for this part of Pennsylvania ($\bar{x}$ goals for 4 counties, range = 17–19). Obviously, my adjustments and assumptions are approximations only, and I would not consider this evidence that the current goals for carrying capacity need to be lowered. Until more precise data are available, the Pennsylvania Game Commission goal of 18 deer/259 ha seems reasonable for the region. I think that lowering deer populations to that level and maintaining them there for several years would allow the forests to develop an understory with a variety of seedlings, shrubs, and herbaceous plants that, in turn, would allow forest regeneration and assure habitat for forest wildlife species, including white-tailed deer.

LITERATURE CITED

BANASIAK, C. F. 1961. Deer in Maine. Me. Dep. of Inland Fish. and Game, Game Div. Bull. 6. 159pp.

BENNETT, A. L. 1957. Deer mismanagement—a threat to sustained yield forestry in Pennsylvania. Proc. Soc. Am. For. 1957:101–104.

BRAMBLE, W. C., AND P. F. ENGLISH. 1948. The forest grazing problem created by deer in eastern forests. Proc. Soc. Am. For. 1948:257–263.

CAREY, A. B. 1983. Cavities in trees in hardwood forests. Pages 167–184 *in* J. W. Davis, G. A. Goodwin, and R. A. Ockenfels, tech. coords. Snag habitat management: proc. of the symp. U.S. For. Serv. Gen. Tech. Rep. RM-99.

CHEATUM, E. L. 1949. Bone marrow as an index of malnutrition in deer. N.Y. State Conserv. 3: 19–22.

CURTIS, R. O., AND F. M. RUSHMORE. 1958. Some effects of stand density and deer browsing on reproduction in an Adirondack hardwood stand. J. For. 56:116–121.

DAHLBERG, D. L., AND R. C. GUETTINGER. 1956. The white-tailed deer in Wisconsin. Wisc. Conserv. Dep. Tech. Wildl. Bull. 14. 282pp.

FARNSWORTH, C. E., AND J. W. BARRETT. 1966. Responses to silvicultural treatment: northern hardwoods type five years after logging. Proc. Sixth World For. Congr.:2338–2343.

FRONTZ, L. 1930. Deer damage to forest trees in Pennsylvania. Pa. Dep. For. and Waters Res. Circ. 3. 10pp.

GRAHAM, S. A. 1958. Results of deer exclosure experiments in the Ottawa National Forest. Trans. North Am. Wildl. Conf. 23:478–490.

HORSLEY, S. B. 1977. Allelopathic interference among plants. II. Physiological modes of action.

Pages 93–136 *in* H. E. Wilcox and A. Hamer, eds. Proc. fourth North American forest biology workshop. Syracuse Univ. Press, Syracuse, N.Y.

———. 1983. Interference with desirable northern hardwood regeneration by herbaceous and woody plants. Pages 81–93 *in* J. Finley, R. S. Cochran, and J. R. Grace, eds. Proc.: regenerating hardwood stands. Pennsylvania State Univ., University Park.

———, AND D. A. MARQUIS. 1983. Interference by weeds and deer with Allegheny hardwood reproduction. Can. J. For. Res. 13:61–69.

JORDAN, J. S. 1967. Deer browsing in northern hardwoods after clearcutting: effect on height, density, and stocking of regeneration of commercial species. U.S. For. Serv. Res. Pap. NE-57. 15pp.

MARQUIS, D. A. 1974. The impact of deer browsing on Allegheny hardwood regeneration. U.S. For. Serv. Res. Pap. NE-308. 8pp.

———. 1975. The Allegheny hardwood forests of Pennsylvania. U.S. For. Serv. Gen. Tech. Rep. NE-15. 32pp.

———. 1981*a*. Effect of deer browsing on timber production in Allegheny hardwood forests of northwestern Pennsylvania. U.S. For. Serv. Res. Pap. NE-475. 10pp.

———. 1981*b*. Management of Allegheny hardwoods for timber and wildlife. Proc. Int. Union For. Res. Organ. World Congr. 17:369–380.

———. 1983. Regeneration of black cherry in the Alleghenies. Pages 106–119 *in* The hardwood resource and its utilization: where are we going? Proc. hardwood symp. of the hardwood research council. U.S. For. Serv., South. For. Exp. Stn., New Orleans, La.

———, AND R. BRENNEMAN. 1981. The impact of deer on forest vegetation in Pennsylvania. U.S. For. Serv. Gen. Tech. Rep. NE-65. 7pp.

———, R. L. ERNST, AND S. L. STOUT. 1984. Prescribing silvicultural treatments in hardwood stands of the Alleghenies. U.S. For. Serv. Gen. Tech. Rep. NE-96. 90pp.

———, AND T. J. GRISEZ. 1978. The effect of deer exclosures on the recovery of vegetation in failed clearcuts on the Allegheny Plateau. U.S. For. Serv. Res. Note NE-270. 5pp.

REXRODE, C. O., AND L. R. AUCHMOODY. 1982. 46 years after storm glaze-damaged black cherry. Pa. For. 72:8–9.

SHOPE, W. K. 1978. Estimating deer population using CIR procedures and age structure data and harvest management decision making from CIR estimates. Trans. Northeast. Deer Stud. Group Meet. 14:28–35.

TIERSON, W. C., E. F. PATRIC, AND D. F. BEHREND. 1966. Influence of white-tailed deer on a northern hardwood forest. J. For. 64:801–805.

Received 10 February 1988.
Accepted 22 December 1988.