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The Impact of Deer on Forest Vegetation in Pennsylvania

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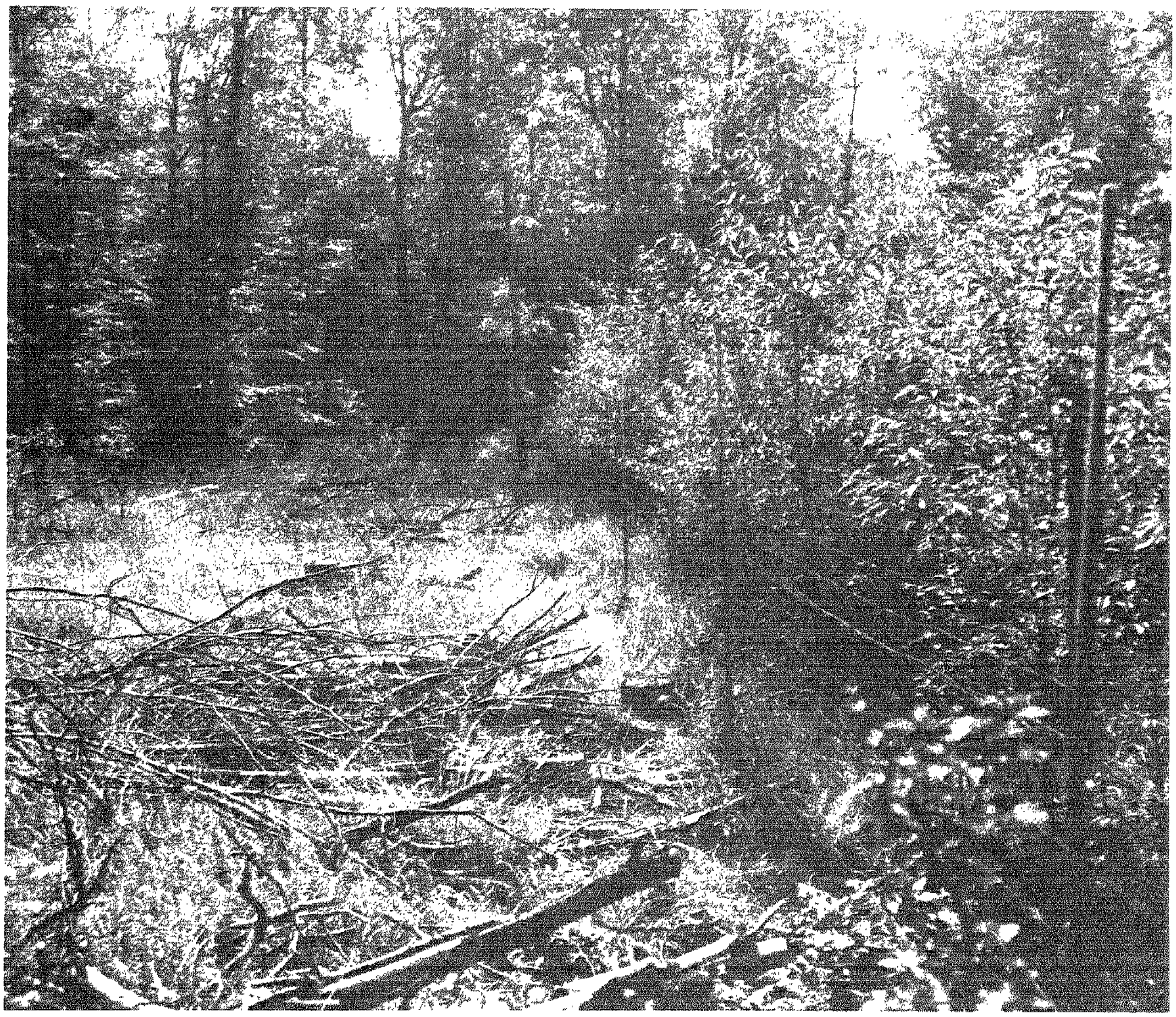

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Abstract

Browsing of tree seedlings by white-tailed deer in the heavily forested regions of Pennsylvania has had a major effect on forest vegetation. In some areas, deer browsing has completely prevented the reestablishment of forest trees following cutting. In other areas, deer have altered species composition, reduced vegetation density and growth, limited the kinds of forest management that can be practiced, and reduced the amount of favorable habitat for other wildlife species such as grouse, rabbits, hare, turkey, and many nongame species. Attempts to protect seedlings from deer are either ineffective or prohibitively expensive. The only long-term solution to this resource management problem is to bring the deer herd into better balance with its habitat.

Introduction

High-quality hardwood forests of the cherry-maple and oak types cover nearly 16 million acres in Pennsylvania. Concentrated in the northern and central portions of the State, they represent one of the few large blocks of contiguous forest land in the Northeast. Yet these forests are surrounded on all sides by the eastern megalopolis—nearly one-third of the entire United States population lives within a day's drive of the region, providing a large and nearby market for forest products, and placing great demands on the forest land for other uses.

Some of the world's most prized hardwood timber grows here—oak and maple for flooring and furniture, ash for baseball bats and tool handles, and cherry for furniture and paneling. Black cherry does not grow in important commercial quantities any other place in the world.

These forests are also of great value for wildlife. Pennsylvania ranks first in the Nation in the sale of hunting licenses. Hunters take 100,000 to 150,000[1] deer annually; other people derive pleasure by photographing or simply observing wild animals in their natural environment.

Unfortunately, Pennsylvania's high deer population creates problems as well as enjoyment. Browsing of plants by deer has affected forest vegetation over a long period (Frontz 1930; Bramble and English 1948; Bennett 1957; Marquis 1975). Understory vegetation is extremely sparse in most undisturbed stands, and new seedlings that appear after forest cutting often are severely browsed. Woody browse production on the Allegheny National Forest is 1.6 to 3.2 times lower, and utilization 2.5 to 9.9 times higher than on other eastern National forests as a result of overuse (Stiteler and Shaw 1966).

The lack of natural regeneration after cutting threatens the very future of our Pennsylvania forests. The problem is becoming critical now because our forests are 50 to 90 years old and rapidly approaching maturity. Many stands will have to be regenerated in the near future. If new stands of trees cannot be reestablished, the future value of the area to all forest uses will be greatly diminished.

This problem did not exist when our present second-growth forests were established. In those days, deer populations were extremely low because of unlimited hunting and natural predators. Current high populations originated in the 1915-1935 era after numerous game laws had been enacted to protect deer from hunting; no doe hunting at all was permitted between 1907 and 1928. During this same period, extensive commercial clearcutting of the original forests provided tremendous quantities of woody browse for deer to feed on, and their population increased drastically. Thus, the problem of overbrowsing became severe after the commercial clearcuttings in the original forest were completed and the newly established second growth had grown out of the deers' reach (Bennett 1957; Marquis 1975).

Pennsylvania's forest lands

Pennsylvania contains within its boundaries 28,769,200 acres, of which 16,816,900 acres, or 58 percent, is forest land; 15,923,700 acres of the forested area is considered commercial forest land. Public forest land, which includes National forests, miscellaneous Federal land, and State land, encompasses 3,821,200 acres; forest industry owns 965,100 acres. The bulk of the commercial forest land, or 12,031,600 acres, is owned by farmers and miscellaneous private groups (Considine and Powell 1980).

Forest management

Management of forest land for the production of timber, wildlife, and other values usually entails one of two primary techniques—even-age silviculture or uneven-age silviculture (U.S. Dep. Agric. 1973).

Under even-age silviculture, trees are grown in stands (areas of 10 to 100 acres) in which all of the trees are essentially the same age. Each stand is cultured by periodic thinnings to remove the poorer quality, slower growing trees, and provide adequate growing space for the largest and most valuable trees. Then, when the majority of the trees mature, they are all harvested within a short period and a new stand of seedlings is started to take their place. The cutting methods used to harvest the mature trees and regenerate new ones may be either clearcuttings or shelterwood cuttings, both of which result in forest openings of considerable size.

Each cutting under even-age silviculture produces both timber and deer browse. The periodic thinnings open the forest canopy, providing light for seedling growth and a resulting several-fold increase in browse production. The final harvest-regeneration cut provides an even larger amount of deer food. Woody browse and herbaceous forage are increased dramatically by these forest openings and food production remains high for 10 years or so after cutting. Some studies have shown deer food production to be 10 to 50 times greater in clearcuts than in uncut areas of comparable size (Halls and Alcaniz 1968; Hosley 1956).

Ideally, harvest-regeneration cuttings in a forest managed for both timber and deer are scheduled so that some forest openings are available to deer at all times, and so that there are about equal areas devoted to each age class of trees. This ensures a sustained yield of both timber products and deer habitat.

[1] These are the reported harvests—actual harvests are substantially higher.

In contrast to even-age silviculture, uneven-age silviculture attempts to maintain trees of several or many ages in the same stand. Each stand is cultured by periodic selection cuttings, which remove some trees from each size class present. This provides adequate growing space for those that remain, and at the same time allows new seedlings to become established in the partial shade of overstory trees. Since the stand is never clearcut, these seedlings must grow under partial shade until they attain a position in the main crown canopy—often 50 to 100 years or more.

Each selection cutting provides browse similar to that from a thinning. But since there is never a clearcut, overall browse production is considerably less than under even-age management. Since regeneration must develop under the shade of overstory trees for a long period, it is usually limited to shade-tolerant species such as beech, hemlock, and sugar maple. The light-demanding species such as black cherry, white ash, yellow-poplar, and red oak are generally much less abundant under uneven-age management (Trimble 1965, 1970).

The light-demanding species tend to be faster growing and are generally the most valuable timber species. Even-age silviculture, therefore, is usually favored where timber production is a major goal of management. But uneven-age management leaves the forest with a more natural or undisturbed appearance, and it is especially useful where esthetic or recreation values are of special importance, for example, in small, privately owned woodlands, or in areas of high recreation use on public forests (Marquis 1976). Deer food production is highest under even-age management because of the periodic large openings. Since there is a wide range of stand ages in a forest area at all times, even-age management is favorable for a wide variety of wildlife species; but there are some—those that depend entirely on mature forest for food and cover—that do better under uneven-age management (Hassinger et al. 1975).

Regeneration requirements

In Pennsylvania's hardwood forests, nearly all tree regeneration is obtained naturally, from seed or sprouts of the existing trees. Foresters encourage this regeneration in various ways. Cutting methods and intensities are varied to provide environmental conditions conducive to seed germination and seedling growth. Since each species has somewhat different requirements, cutting will be varied to provide conditions more favorable to the desired than to the unwanted species. Occasionally, herbicides may be used to eliminate undesirable trees or herbaceous plants that interface with regeneration.

Regardless of the exact technique used, it is always necessary to establish many more seedlings than will be required when the trees reach mature size. For example, a mature stand of Allegheny hardwoods may contain only 100 trees per acre, but there may have been 10,000 to 100,000 seedlings per acre when that stand first regenerated. Many stems die as the stands grow. Some die from overcrowding, some are killed by insects and diseases, some are eaten by deer, some are broken by ice and snow, and some are felled by lightning. But the excess numbers are not a loss—while they lived they helped prevent erosion and retain nutrients on the site; the crowding helped the survivors to grow straight and tall with few branches that would be defects in the finished lumber; and the excess seedlings provided food and cover for many types of wildlife.

This abundance of seedlings makes it possible to manage a forest for both timber and deer at the same time. So long as a balance is maintained between the age and structure of the vegetation and deer numbers, benefits can be obtained from both resources indefinitely.

Most seedling regeneration in Pennsylvania's hardwood forests is started under the shade of the overstory trees, while there is a seed source still present and so that the partial shade protects the germinating seed from the hot, dry rays of direct sunlight. Some seedlings can get started in the open too, but the numbers that originate in this way are seldom adequate to establish a new stand. Thus, the success of all cutting methods, including clearcutting, depends on the establishment of seedlings beneath the canopy of the existing overstory. If large numbers of seedlings cannot be established in the understory, no cutting method will regenerate a new stand satisfactorily.

Problems Created by Deer

Natural regeneration

As mentioned previously, most regeneration in Pennsylvania's hardwood forests is obtained naturally. However, an overpopulation of deer can prevent successful natural regeneration of areas that have been cut. The effect of deer on regeneration has been thoroughly documented through the use of exclosures where deer are prevented from browsing in a certain area. Exclosure studies by Jordan (1967), Shafer et al. (1961), Richards and Farnsworth (1971), Grisez (1950), and Marquis (1974) have shown that deer can reduce the height and density and change the species composition of seedlings and sprouts. Browsing has been shown to be a major cause of regeneration failures. Marquis (1981) found that 62 percent of the clearcuts he examined on the Allegheny National Forest were unsatisfactorily stocked with preferred species. At least 87 percent of the unsatisfactorily stocked clearcuts had failed to regenerate because of deer browsing, since regeneration was satisfactory inside the fences in those areas.

After clearcutting, the large amount of sunlight reaching the forest floor causes a rapid growth of seedlings, sprouts, and herbaceous plants, which provide large amounts of succulent and nutritious food for the deer. Normally, there would be enough seedlings so that deer could browse and still leave plenty to establish a new stand of trees. Understory vegetation in surrounding areas provides additional food sources for deer. But Pennsylvania's high deer population over the past several decades has virtually eliminated understory growth in many timber stands. Deer in search of food congregate in any openings that are cut, and may severely overbrowse the vegetation, sometimes preventing tree regeneration entirely.

Even in those areas that regenerate to trees, deer browsing may influence species composition. Research has shown that deer have a preference for certain species of seedlings and sprouts over others (Healy 1971; Bramble and Goddard 1953; Cook 1946; Brenneman 1975). The species most desirable for timber production include black cherry, sugar maple, red maple, white ash, and northern red oak; these species produce the highest quality sawtimber, but are also the same species preferred by deer. Excessive deer browsing eliminates most of the desirable species and allows other less desirable species like beech and striped maple, and herbaceous growth such as ferns, grasses, goldenrod, or aster to proliferate and eventually take over the site (Marquis and Grisez 1978). Such areas may remain devoid of trees for many years and are not very productive of either timber or deer.

Studies have shown that the stands most likely to regenerate satisfactorily are those with an abundance of seedlings in the understory before the final harvest cutting (Grisez and Peace 1973)—these seedlings are called advance regeneration. Usually advance regeneration develops well before the overstory reaches maturity. Often, commercial thinnings made to favor the most desirable overstory tree species and increase their growth allow enough additional sunlight to reach the forest floor to stimulate germination and growth of new tree seedlings. The last thinning or shelterwood seed cutting is made specifically for this purpose. Once these advanced seedlings are established, the remaining overstory can be removed and these already established seedlings will grow to form the next stand on that site.

Under conditions where there are too many deer, it is difficult to obtain advanced regeneration of desired species, because deer eliminate the seedlings by their browsing. Such stands may have no understory at all. Further, undesirable plants such as fern, grass, striped maple, and beech root suckers—which deer eat less frequently—may expand to fill the space that would otherwise be occupied by desirable seedlings. Once these undesirable plants are established in the stand, foresters may be forced to spray the area with herbicides to kill them, at considerable expense to the landowner.

Some foresters are reluctant to manage their stands at all in areas of high deer population, simply because each thinning increases the chance of developing an undesirable understory and eventually requires large investments in herbicides or other measures to ensure regeneration when the stand is harvested.

Artificial regeneration

Artificial regeneration (seeding or planting) is even more difficult to obtain than natural regeneration where deer populations are high. Seedlings that are planted are browsed very heavily by deer unless the seedlings are protected by individual cages or the entire area is fenced. In an experiment in Carbon County, red pine was planted in an abandoned field in 1950. Part of the area was protected from deer browsing with a fenced exclosure. Eight years later, the average height of red pine inside the exclosure was 11 feet while those outside averaged only 2½ feet and were misshapen from heavy deer browsing (Grisez 1959). Similar damage in Christmas tree plantations and other planted areas has been reported; as high as 86 percent of the planted trees were damaged by deer browsing (Farrand 1959). In a red oak and white ash planting in central Pennsylvania, deer browsed nearly 70 percent of the seedlings within the first growing season after planting (Marquis et al. 1976); more than 70 percent of the unprotected seedlings died within four years, whereas only 14 percent of the protected seedlings died. Therefore, artificial planting of tree seedlings in areas of high deer density is futile unless they are protected from deer browsing.

Limits on silviculture

Another problem caused by overpopulation of deer in forested areas is the limit placed on the silvicultural systems that can be used successfully. Most forest land in Pennsylvania today is managed on the even-age system, which was described previously. The problem and difficulties that arise from the deer herd under this system have already been covered. Even-age management generally seems the best silvicultural system for both timber and deer in Pennsylvania.

However, there are certain times when uneven-age management would also be desirable. For esthetic reasons, uneven-age management is more acceptable along highways, streams, or lakes, or in recreation areas. The northern hardwood or Allegheny hardwood forest type—which includes shade-tolerant species such as sugar maple, hemlock, and beech—is well adapted to uneven-age management. However, under the browsing pressure of the deer herd, this type of management is not possible because uneven-age management depends on the periodic regeneration of desirable tree seedlings in the canopy openings made by selection cuttings. Because seedlings grown in partial shade grow slowly, they are subject to deer browsing for many years, and deer eliminate the desirable seedlings before they can grow out of reach. This makes uneven-age management impractical in areas of heavy deer population.

Similar problems arise in natural areas and wilderness areas. Perpetuation of these undisturbed forests requires that shade-tolerant seedlings and saplings in the understory replace trees that mature and die or that are killed by natural causes. But excessive browsing eliminates seedlings of shade-tolerant species such as sugar maple and eastern hemlock, leaving only the less palatable beech (Hough 1965). These natural and wilderness areas will be far less attractive and useful for their intended purposes if browsing continues over an extended period.

Economic impact

Delays in harvesting caused by deer browsing increase the rotation age (number of years required for timber to reach maturity) and complicate present and future management. Whether employed by public agencies or private industry, all foresters have an overall plan for the lands they manage. Federal or State foresters may be required to clearcut and thin a given amount of acreage each year to provide income from timber sales and to improve and maintain suitable wildlife habitat. Foresters with industry often must maintain a constant supply of pulpwood or sawtimber, or both, to keep sawmills and pulpmills in production. If foresters are not able to supply the necessary volumes, operations that affect hundreds or even thousands of jobs may be interrupted. This considerable loss of income eventually would be passed on to the consumer through an increase in the cost of the finished product, whether it be furniture, home building supplies, or paper products.

Delaying cutting of a timber stand that is mature also represents a monetary loss to the landowner. Once the timber is mature, the quality and growth of the individual trees decrease rapidly, and there is increased danger of disease, rot, windthrow, and lightning damage. Therefore, the income derived from the sale of the timber will also decrease.

In addition to causing cutting delays which increase the rotation age, deer browsing reduces timber value by influencing changes in species composition to less valuable species, and by reducing stocking. There have been several attempts over the years to estimate the economic loss from these changes, but the values and techniques used have varied considerably. McCullough (1952) estimated the losses on forest land caused by deer at $0.87 to $23.19 per acre depending on the stand type. At today's prices, this figure would be substantially higher. Behrend et al. (1970) estimated that a 10-year delay in rotation in a northern hardwood stand would amount to $700 per deer and a 120-year delay (rotation length), $8,800 per deer (assuming a density of 27 deer per square mile). Marquis (1981) estimated the average value of timber production lost from deer browsing in northern Pennsylvania at $1,075 per acre—about half the total stand value. This represents a loss of about $13 per acre per year for all forested land in the affected area. One reason that more work has not been done on the economic aspects of deer damage is the difficulty of predicting future yields when working with rotation lengths of 80 to 120 years. We hope more attention will be directed to this area in the future.

Offsetting the timber losses to some extent are the values generated by the recreational uses of the deer herd. Unfortunately, these values usually do not accrue to the landowner who suffers the losses.

Attempts to Achieve Relief

Many techniques to protect seedlings or circumvent deer browsing have been tested. These range from chemical repellents and fencing to the use of different cutting methods and encouraging hunting in severely browsed areas.

Repellents

Many types of chemical taste and odor repellents have been tested; all of them contain one of these active ingredients: Putrescent whole egg solids (BGR), zinc dimethyl dithiocarbamate cyclohexylamine complex (ZAC, ZIP), tetramethylthiuram disulfide (THIRAM, TMTD, ARASAN-42), or bone tar oil (MAGIC CIRCLE)[2], Formulations marketed under various trade names differ with respect to stickers, colorants, surfactants, etc. Exotic materials such as lions' dung and lions' blood also have been tried.

Although good results have been obtained with these materials in other parts of the country where alternative foods are readily available, none of these repellents has been effective in Pennsylvania's areas of high deer population, where vegetation has been overbrowsed for many years. Further, repellents must be reapplied at frequent intervals if protection is to be continued, making this a costly and time-consuming venture (Dudderar 1977; Dietz and Tigner 1968).[3, 4]

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[2] The use of trade, firm, or corporation names in this paper is for the information and convenience of the reader. Such uses does not constitute an official endorsement or approval of any product or service to the exclusion of others that may be suitable.

[3] Kinsey, Charles. 1977. Development of an effective deer barrier. Minn. Wildl. Serv., For. Wildl. Res. Job No. 24, Prog. Rep. (Unpublished).

[4] Ernst, Richard L. 1978. Progress report: Evaluation of deer protective devices. Unpublished Off. Rep. Northeast. For. Exp. Stn, Warren, Pa.

Fencing

Fencing that surrounds an entire regeneration area is quite effective as a means of protecting seedlings from deer browsing. The most effective is a cattle-wire fence 8 feet or more tall, but certain types of nylon or plastic netting 8 feet tall also will work. The cost of each type of fencing is $150 to $250 per acre or more, even when standing trees are used as posts (Grisez 1959).[5]

Electric shock or outrigger fence designs also have been tested as a means of reducing the cost of fencing (Dudderar 1977; Seamans 1951; Kinsey 1977). A major difficulty with electric fencing is shorting of the charger by vegetation or snow, though recently developed chargers may eventually overcome this problem. Recent trials with electric fencing using high tensile strength wire and solar cell battery chargers suggest that this technique may prove effective at a lower cost than other fencing (Dowlin 1981; Brenneman 1981).

Another form of fencing that has been tested with some success is a cage of wire or plastic mesh that protects an individual seedling. The most effective is a cage of either chicken wire or plastic mesh 5 to 6 feet tall that protects the seedling until it grows out the top, by which time it is above the reach of deer (Marquis 1977). These cages also are very expensive—about $2 to $2.50 per seedling. Individual cages are useful primarily where small open areas are interspersed among areas of successful regeneration. Where more than 100 cages are needed per acre, area fencing usually is cheaper and gives better results.

Fertilization

Fertilization is one technique that foresters are using to minimize deer damage. In clearcut areas where there are seedlings that are being browsed severely, an application of nitrogen and phosphorous fertilizer will stimulate rapid height growth (3 to 4 feet per year) of species like black cherry. After fertilization, many seedlings will grow out of reach of deer in a couple of years, rather than the 5 to 6 years normally required (Auchmoody 1978). Although it provides no guarantee that seedlings will escape unharmed, fertilization does reduce the damage considerably. It can only be used where a sufficient number of seedlings are already established—fertilization does not increase the number of seedlings.

Fertilizers can be applied by helicopter for a little over $100 per acre, making this technique a far better investment than any form of fencing. But even $100 per acre is a formidable investment when applied over thousands of acres of forest land, especially when the crop of timber resulting from this investment will not be harvested for 80 or more years. A landowner could put that $100 in a bank and earn $10,000 interest (even at a low rate of 6 percent) in 80 years—more than the timber will be worth.

Concentration of hunters

Some degree of relief from browsing damage can be achieved by encouraging hunters to go into areas where the damage is greatest. Often these are the less accessible areas. Both public forestry agencies and private timber industries have developed extensive public information programs over the past few years to inform hunters of areas of high deer populations, sending literature with doe permits and providing maps that show where these areas are located and how to reach them. In many cases, roads have been plowed of snow during the antlerless deer season to ensure accessibility, and one industry has actually provided transportation or prizes for those who hunt on its lands.

Although these programs are helpful and will undoubtedly be continued, they are costly and cannot provide a concentration of hunters on all of the vast acreage where deer damage is occurring.

Silvicultural techniques

By far, the best technique for obtaining tree regeneration is careful manipulation of vegetation with cutting practices. By accurately assessing the ecological conditions of a particular area, foresters often can prescribe a treatment that will result in successful regeneration despite a large deer herd. Basically, this requires that an extremely large number of seedlings be established, and that—once established—they be stimulated to grow as rapidly as possible. When this is done, the deer simply cannot eat all of the seedlings before some have grown out of reach. The need for rapid growth generally restricts foresters to even-age silviculture.

Stands that regenerate successfully usually contain large numbers of advance seedlings beneath the overhead canopy before cutting, and do not contain interfering plants such as grass, ferns, striped maple, and beech root suckers. Where these conditions exist naturally, clearcutting will produce satisfactory regeneration (Marquis et al. 1975). Foresters estimate that 20 to 30 percent of the northern forest are in this category.

Some stands that lack interfering plants, but do not contain adequate numbers of advance seedlings for clearcutting, can be treated by a technique called shelterwood cutting. This entails a crefully planned sequence of several cuttings, the first of which opens the crown canopy to provide additional sunlight and moisture for new seedlings to get started while maintaining enough shade to keep seedlings small and rela-

[5] Allegheny National Forest. Personal communication from J. Hockinson, Timber Staff Officer, Allegheny National Forest, USDA For. Serv., Warren, Pa., 1977.

tively unattractive to deer. When adequate numbers of seedlings are established, the remaining overstory can be removed as before and the seedlings then grow quickly out of the reach of deer (Marquis 1979). An additional 20 to 30 percent of our northern forest can be treated in this way to obtain successful natural regeneration.

Unfortunately, the remaining 40 to 60 percent of the forest area in northern Pennsylvania cannot be regenerated successfully by either technique, and many years of research suggest that so long as the deer population remains at current high levels, no silvicultural technique is likely to succeed on these areas without large expenditures for fencing, herbicide, or fertilization.

Deer Harvest to Achieve Population Balance

The only long-term solution seen is bringing the deer herd into better balance with its habitat and with other forest resources. This means that deer harvests must be increased in some areas to reduce the population to a level compatible with the vegetation. The Pennsylvania Game Commission, State and Federal forestry organizations, and the forest industry are working to bring this about in a manner that fully recognizes the value of the deer herd as well as other resources.

The potential benefits of this program are many. Not only will forest regeneration be assured, but cover and food for other types of wildlife—grouse, rabbits, hares, squirrels, turkey, and many nongame species—will be improved. Deer themselves will benefit from the improved nutrition—with larger size and better antler development at a younger age.

Of course, lower deer populations could mean somewhat lower hunter success, but the full impact is not completely known at this time. The reduction in harvest should not be proportional to the reduction in population. Improved nutrition should increase the number of fawns born to each doe and reduce winter starvation. Thus, the higher birth rate in the spring and lower winter mortality could maintain an acceptably high population for fall hunting, even though the population is reduced appreciably over the winter when much of the browsing damage occurs. Additional research to define the optimum deer population level is now underway.

In any case, the cooperation and understanding of those parties interested in deer and those responsible for tree regeneration will be required to solve this natural resource problem in a manner that is fair and equitable to all. The solution must provide full recognition of all of the resource uses of our forest lands.

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7 p., (USDA For. Serv. Gen. Tech. Rep. NE-65)

Browsing of tree seedlings by white-tailed deer in the heavily forested regions of Pennsylvania has had a major effect on forest vegetation. In some areas, deer browsing has completely prevented the reestablishment of forest trees following cutting. In other areas, deer have altered species composition, reduced vegetation density and growth, limited the kinds of forest management that can be practiced, and reduced the amount of favorable habitat for other wildlife species such as grouse, rabbits, hare, turkey, and many non-game species. Attempts to protect seedlings from deer are either ineffective or prohibitively expensive. The only long-term solution to this resource management problem is to bring the deer herd into better balance with its habitat.

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Headquarters of the Northeastern Forest Experiment Station are in Broomall, Pa. Field laboratories and research units are maintained at:

- Amherst, Massachusetts, in cooperation with the University of Massachusetts.
- Beltsville, Maryland.
- Berea, Kentucky, in cooperation with Berea College.
- Burlington, Vermont, in cooperation with the University of Vermont.
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