ANIMAL DAMAGE TO BIRCH

by JAMES S. JORDAN and FRANCIS M. RUSHMORE, Northeastern Forest Experiment Station, Forest Service, U. S. Department of Agriculture. Dr. Jordan, a Wildlife Biologist, is at the Station's research unit at Warren, Pa.; Mr. Rushmore, a Silviculturist, is at the Station's research unit at Orono, Maine.

A RELATIVELY FEW animal species are responsible for most of the reported damage to the birches. White-tailed deer, yellow-bellied sapsuckers, porcupines, moose, and hares are the major animals involved. We will review reports of damage, discuss the underlying causes, and describe possible methods of control.

For example, heavy deer browsing that eliminates birch regeneration can be especially damaging, regardless of how well birch is managed. Here the immediate action may well be direct control of the deer population; but the basic long-term need is for action through a better understanding of deer and plant ecology.

WHITE-TAILED DEER

(Odocoileus virginianus)

Yellow and paper birch are important browse species for deer *(Hosley 1956, Stiteler and Shaw 1966)*. Yellow birch is a preferred food of deer in northern forests; paper birch in these forests is a second-choice deer food, but it is much used by deer in some sections *(Hosley 1956)*. Browsing of yellow birch by deer in the United States and Canada often results in the mortality or reduced height of seedlings, both natural regeneration and plantations *(Christ 1959, Curtis and Rushmore 1958, Drinkwater 1957, Eyre and Zillgitt 1953, Jacobs 1965, Jarvis 1957, Stoeckeler et al. 1957, von Althen 1964, Wang 1968)*. The effects of deer browsing on populations of yellow birch seedlings may be so severe as to prevent regeneration *(Graham 1954)*. Paper birch apparently is affected similarly by heavy browsing *(Bjorkbom 1967 and 1968, Graham 1958, Stoeckeler 1955)*, but less information is available on the subject of deer damage to this species.

Yellow birch is more resistant to the effects of deer browsing than paper birch, and both species are less resistant than red maple *(Gill 1957)*. Browse-clipping studies of individual seedlings indicate that if paper birch is to be managed for timber, only light deer browsing can be permitted *(Aldous 1952)*. Yellow birch apparently has not been studied from this aspect, nor is there available information about the form of sapling- and pole-size yellow and paper birch that were browsed as seedlings.

Discussion

Most of the above reports are from studies made after damage to commercial tree species was observed over large areas. The gross effects of very heavy browsing by deer (hedged seedlings and browse lines) are now well known from some of these and other reports. Under such conditions, regeneration of yellow and paper birch is not likely to survive unless the deer population is controlled.

Excessive deer browsing of commercially important species occurs when there is a severe imbalance between the deer population and its food supply. Under normal conditions the deer spread their feeding over a large number of plant species, most of which are noncommercial species. The effect of slight overbrowsing on any one species is usually self-correcting under these conditions, because the deer select their food from among more abundant species.

However, when the deer population is too large, the effects of overbrowsing begin to accumulate. The incidence, and then the intensity, of browsing on noncommercial species slowly increase until heavy mortality within species occurs. In the meantime, browsing on commercial tree species increases

as some of the noncommercial browse plants become scarce. First the height of seedlings is reduced until there is a preponderance of browsed seedlings entirely within the reach of deer; the form of seedlings is often changed to produce a variety of undesirable conditions. Then the rate of mortality among seedlings increases until it exceeds the rate of replacement by new seedlings. Deer preferences among food species gradually disappear; finally, it becomes only a matter of which food species are most resistant to the effects of heavy browsing and which among the once low-preference browse species are most digestible. Under these conditions, deer can easily prevent the survival of all but a few scattered woody browse plants.

Large disturbances of the vegetation can change the order of events to produce even greater modification of this somewhat classic pattern. Fire, blowdowns, land clearing, farm abandonment, changes in deer harvest regulations, and the management of timber are examples of natural events and human activities that can change the pattern in different ways, even to the extent of reversing it. These influences probably are responsible for some of the place-to-place variation in the amount of deer damage reported. They also increase the difficulty of determining the underlying cause of deer damage.

Although an overpopulation of deer is almost always suggested as the reason for excessive damage to some particular valuable species—such as birch—this may not be the underlying problem. The problem may be a preference by deer for the particular species of interest, a high susceptibility of that species to the effects of browsing, a low density of seedlings of that species before the damage was reported, a deer range in poor condition, or some complex mixture of several of these factors.

Thus the term "overpopulation of deer" is a relative one. Damage to seedlings of a single commercial tree species, to those of several commercial species, or to all woody browse species may each be attributed to an overpopulation of deer, yet each might represent a deer population of different size. It depends upon where the primary interest lies.

Influence of Timber Management

Timber-management activities sometimes lead to deer damage of commercial tree species. Clearcutting in patches for birch regeneration, for example, produces islands of new and concentrated food supplies, and deer are invariably attracted to them by the browse from felled trees and later by the new growth of plants. Our own general observations of deer use of clearcut patches in the northern hardwood type lead us to believe that the patches virtually funnel deer to this new food supply. The patches seemed to constitute naturally baited areas for deer because the variety and concentration of plants provide an excellent source of browse that can be obtained with minimum effort.

We suggest that the successful establishment of yellow and paper birch in clearcut patches may depend largely on two factors: (1) the level of deer damage in the general area of the patches immediately before cutting, and (2) the density and stocking rate of woody browse plants, including yellow and paper birch, in the clearcut patches two or three growing seasons after cutting.

Unless deer damage before cutting is at a very low level, the density of woody browse stems in the patches may have to be very high (at least 200,000 stems per acre?). Even if damage before cutting is at a low level, a density of at least 100,000 stems per acre might be necessary because deer browsing is still likely to be concentrated in the clearcut patches. If deer damage is at a low level before cutting and the area density of browse stems in the patches is also low, the effects of concentrated browsing may prevent or at the very least delay the regeneration of yellow and paper birch.

Deer Damage Control

The best control of deer damage to yellow and paper birch is damage prevention. This requires knowledge of: the density of the deer population; the condition of the deer; the condition of the deer food resource (incidence of browsing and area density of important deer forage species); and the density per acre and intensity of browsing of reproduction of commercial tree species.

Browse information may be collected by the use of a trend survey such as currently used on the National Forests of the Northeast *(Shaw and Stiteler 1962)*. A count of deer pellet groups on plots since the last leaf fall *(Krefting and Shiue 1960)* will yield an index to the deer population in the areas of

interest. And the condition of deer may be determined from the examinations of deer made by game department biologists during the annual hunting season. Evaluation of this information is necessarily subjective, but a little experience will permit reasonably accurate evaluations of the need for preventive action.

Prevention of damage to yellow and paper birch reproduction may be accomplished in one of the following ways: (1) increase the deer hunting pressure within existing deer harvest regulations, (2) utilize special habitat practices to increase the yield of deer foods, (3) increase the reduction in the level of the winter deer population, (4) fence to exclude deer from regeneration areas, and (5) develop systems of deer-habitat management.

Measures to increase hunting pressure.—Hunting pressures can be increased by: providing good access roads; using signs to designate the areas and to identify all interior access roads and trails; providing hunters with scale maps of the areas, showing roads, parking areas, trails, cutover stands, permanent openings, waterways, and all other significant features to facilitate travel and orientation within the areas; and publicizing the availability of the area for deer hunting.

Special habitat practices.—There are several special practices that may reduce the damage hazard to reproduction. Clearcutting buffer areas in stands near the regeneration cuttings may dilute the impact of deer browsing. Also, timber-stand-improvement browse cuttings may be made in poletimber stands *(Jordan et al. 1965)*. In this practice all stems except the future crop trees are felled in winter to produce a new source of browse in the tops of felled trees and later in the stump sprouts and new growth of understory vegetation.

Almost any practice that will increase the yield of deer food may reduce the damage hazard. However, an increase in food production may also lead to an increase in deer production; thus the deer population must be held stable through adequate deer harvests.

Reduction in the winter deer population.—If the cause of deer damage is obviously an overpopulation of deer, there is also likely to be evidence of widespread damage and a history of overbrowsing of commercial and noncommercial plant species alike. The best available immediate solution is a heavy reduction in the winter deer herd. If this can be accomplished, there is likely to be a dramatic improvement in the condition of the deer *(Hesselton et al. 1965)*, but probably a much slower recovery of the range. There may also be some relief from damage to regeneration after clearcutting. And use of special habitat practices may hasten range recovery.

Damage that occurs in the vicinity of winter deer yards is a special case. Here the primary interest is in the survival of the deer rather than in reducing their numbers. Cutting practices to increase the production of hardwood deer browse within and adjacent to yarding areas has been described *(Laramie 1968)*. The solution of deer food problems in and adjacent to yarding areas probably would also reduce damage to timber regeneration in the vicinity of such areas.

Fencing to exclude deer.—This is a direct action that can be taken to prevent or to control deer damage to yellow and paper birch. Fencing would seem to have an application only in special cases: for example, areas under artificial regeneration.

There is no evidence that fencing has yet been used in the management of yellow and paper birch. However, the use of fencing to prevent deer damage to timber regeneration in European countries is well known, and different kinds of fencing have been tested experimentally in the United States for their effectiveness in excluding deer *(Blaisdell and Hubbard 1956, Jones and Longhurst 1958, Longhurst et al. 1962)*. Fences have also been used to protect research study plots *(Grisez 1959a and 1959b, Jordan and Sharp 1967, Krefting 1951)*.

Fences are generally of two kinds: high fence (6 to 8 feet), and low fence (about 4.5 feet) to which an outrigger is attached at an angle of 45° or less. Wooden or steel posts, or trees, may be used to support the fence. The total direct cost per linear foot of fencing will depend on the strength and durability of the materials used and the labor costs to erect and maintain the fence.

It may be assumed that the cost of fencing today is at least as high as 33 cents per linear foot. At this rate the cost of fencing a 10-acre clearcut would be $871 or $87 per acre; the cost of fencing a 100-acre clearcut

would be $2,761 or $28 per acre. Thus, because of its high cost, fencing in timber management should be considered as a last resort. Moreover, fencing may even add to the problem by reducing the acreage available for deer browsing.

Systems of deer habitat management. — Fencing, emergency feeding of deer, or heavy reduction in the winter deer population all fail to correct the cause of overbrowsing. Such alternatives are sometimes the only practical ones available where deer damage is a serious matter, though none of them offers a real solution to the problem of coordinating the production of timber and the production of deer. Any long-term solution of this problem is likely to require that any expedient action to control deer damage be accompanied by concerted efforts to contain the problem, if at all possible, through both improved silvicultural methods and the development of systems of deer habitat management. Admittedly, the knowledge needed to develop complete systems of deer-habitat management is not yet available, but planned management of the deer population through habitat manipulation will be required to achieve a permanent solution to the browsing problem in timber management.

YELLOW-BELLIED SAPSUCKER (*Sphyrapicus varius varius* L.)

Sapsucker damage occurs when the birds drill holes in the bark of living trees to feed upon sap and bark tissues. On severely damaged trees the drilling forms a pattern of rows and columns of closely spaced holes, forming a band that extends partly or completely around the bole *(Kilham 1964, Shigo 1963)*. In the severest cases, the many individual wounds apparently combine to girdle the tree. Other damaging effects of drilling are decay, formation of cavities, stain, curly grain, adventitious branching, reduction in tree vigor *(McAtee 1911, Rushmore 1969)*, and rinkshake *(Jorgensen and Lecznar 1964, Shigo 1963)*.

This sapsucker is the only one of four subspecies that occurs in eastern North America *(Howell 1952, McAtee 1911)*. Its summer range extends from the East Coast nearly to the West Coast, from about 40° to 50° N. latitude in the East and about 52° to 63° N. in the West, as well as along the Appalachian Mountains south to about 35° N. Approximately two-thirds of the summer range in eastern North America lies within the northern forested regions. Sapsuckers are here from about mid-April until late September or early October.

Damage to Yellow and Paper Birch

Sapsucker damage to orchard, shade, and forest trees has been recognized for more than a century. But it was not until the early 1900's that the scope and importance of the damage to forest trees became generally known *(McAtee 1911)*. At that time it was estimated that sapsuckers damaged at least 10 percent of the trees within their range, and that in some areas more than 90 percent of the trees sustained damage.

Paper, yellow, and gray birch are the favorite food species of the sapsucker on the Penobscot Experimental Forest in Maine *(Rushmore 1969)*. A similar preference for these species was observed in New Hampshire *(Kilham 1964)*. Paper birch appeared to be the most preferred among all species on the Penobscot Forest. Of 102 paper birch trees that sapsuckers had already damaged by 1964, 52 had died or were near death. It was expected that additional mortality will occur among the survivors in succeeding years. Intensive feeding occurred on paper birch trees ranging from 4 to 16 inches d.b.h.

Sapsuckers commonly fed on the same birch trees in successive years *(Rushmore 1969)*. When a tree was killed, the birds transferred their intensive feeding to other trees. Sapsuckers are reported to be attracted to trees that have been wounded by other agents *(Kilham 1964)*, but this is not an essential condition in their selection of trees *(Rushmore 1969)*. Many birch trees were tapped in the process of selecting favorite trees, in casual feeding, and while members of a family group waited for an adult bird to leave a favorite tree.

Sapsuckers were found to be highly territorial, and to do severe damage to birches within their territories. A study of 23 territories on the Penobscot Forest showed that they averaged 7.6 acres in size. The same family of sapsuckers occupied a territory throughout the summer. And the same terri-

tories were used year after year. A survey of the Forest in 1966 indicated that sapsuckers used about 47 percent of the area.

In general, sapsuckers exhibited a seasonal pattern of feeding on the Penobscot Forest. Beginning in early spring, they fed on hemlock, spruce, and aspen for several weeks. From May to at least mid-June, red maple was heavily used. By late May the birches had become increasingly important and heavy use of these continued throughout the summer. In dry years, sapsuckers turned back to feeding on hemlocks, but later returned to the birches. The birds commonly drilled into branches of birch trees when the trunk no longer yielded sap. At times, sapsuckers removed the bark from between vertical columns of drill holes, enlarging the holes to form strips about 0.5 to 1.25 inches wide and several inches long.

The rate of mortality among trees damaged by sapsuckers was much higher among hardwoods species, presumably because these were used over a longer period of time. Mortality rates among damaged trees in a sample of nesting territories was as follows: gray birch 67 percent; paper birch 51 percent; red maple 40 percent; red spruce 3 percent; and hemlock 1 percent.

Discussion

The impact of sapsucker damage on timber-management objectives for yellow and paper birch has not been determined. We do know that sapsuckers are common summer residents in northern forested areas, that birch species apparently are a preferred source of food, and that damage is common. Thus mortality, reduced growth, and reduction in log grade probably constitute a real loss in the yield and quality of these species.

Information about the extent of sapsucker damage and sapsucker-induced mortality is being collected as part of the current forest survey of Maine. When completed, this survey will permit estimates of the extent of sapsucker damage in Maine, and may show whether or not remedial action is necessary.

Sapsucker Damage Control

No sapsucker control efforts have been attempted in northern forests, nor has much reearch been devoted to the development of control methods. If control proves desirable, the possibilities of silvicultural control need to be investigated.

For example, even-aged management tends to reduce the amount of hemlock; since hemlock is heavily used by sapsuckers in the spring when they are establishing their territories, sapsucker damage may be reduced under even-aged management or in stands low in proportion of hemlock. Even-aged stands may also have fewer trees suitable for the construction of nest holes, and thus may be less subject to damage. And we need to know whether the removal of heavily damaged favorite trees in a TSI or thinning operation will result in damage to new trees in that stand or in the relocation of sapsuckers to other stands.

Manipulation of sapsucker habitat through silvicultural techniques will almost certainly be more effective than any type of direct control and much more acceptable to non-timber users of our forest lands.

OTHER ANIMAL SPECIES

The total damage to yellow and paper birch by other species may ultimately prove to be greater than that caused by deer and sapsuckers. But published reports of damage by other species are mostly about local occurrences; there are relatively few of them for each species; and they usually describe the kind of damage that is highly visible, such as evidence of overbrowsing, girdling, or bark stripping. What is generally lacking are reports on surveys of the incidence and effects of damage to forest stands over large areas, including the kinds of damage that are less visible and less easily identified—such as the loss of small seedlings and seeds as a direct result of animal feeding. This kind of damage is not often reported, yet it may be important.

The following animal species are either known to cause damage to yellow and paper birch, or they may be a potential cause of damage because of their feeding habits.

PORCUPINE
(Erethizon dorsatum)

Damage to hardwood trees of any size—from sapling to sawtimber—occurs when porcupines debark portions of the stem or main branches to feed on the cambium. Debarking occurs mostly in winter and often results in

lowering the quality of timber and in reducing growth and merchantable height. In some instances the trees are killed. Damaged trees may be weakened or deformed and made susceptible to breakage and to insect and disease attacks *(Hepting and Jemison 1958, Krefting et al. 1962)*.

From a study of porcupine damage in a second-growth northern hardwood-hemlock stand in Wisconsin, it was found that yellow birch was among the three species that sustained the greatest economic loss *(Krefting et al. 1962)*. The three species comprised about 84 percent of the total number of trees in the stand. The damage to yellow birch was heaviest in trees of small sawtimber size. Paper birch was not damaged. In the same report it was estimated that, on National Forests in the Lake States, 534,000 acres sustained heavy and medium porcupine damage in 1960.

Evidence of feeding over a period of years has been found *(Brander and Stearns 1963)*, indicating that porcupines tend to return to the same trees. It was concluded that, with a stable population of porcupines, only a small number of previously unused trees would be gnawed in any single winter. However, populations larger than 1 porcupine per 10 acres may result in serious damage to northern hardwood timber *(Stoeckeler 1950)*.

Organized hunting *(Krefting et al. 1962)* and use of sodium arsenite implanted in apples *(Dodge 1959)* have both been reported as successful temporary measures to control porcupine damage. But biological methods of control would seem to be preferable.

The fisher *(Martes pennanti)*, restocked on the Nicolet and Ottawa National Forests in Wisconsin and Michigan, apparently is becoming effective in controlling porcupines there *(Olson 1966)*. The same author reported that the number of porcupines had declined in those areas of the Adirondacks in New York where the fisher had made a comeback, but that porcupines were still abundant in the Catskill Mountains where the fisher did not occur. And porcupines of the Superior National Forest in Minnesota were reported no longer to be a problem after the fisher made a natural recovery.

A long-term study of the fisher in Maine led to an observation that in places where they were abundant for 10 or 12 years, the porcupine was scarce *(Coulter 1959)*. However, the author also cautioned against restocking fishers in any area without thorough evaluation of objectives, land uses, attitudes, and prospects for control by fur trappers *(Coulter 1966)*.

MOOSE
(Alces alces)

Birch species are important in the diet of moose. In Newfoundland, paper birch is a favorite browse species *(Bergerud 1968, Dodds 1960, Pimlott 1965)*. It was overbrowsed where the moose population was high and its growth was severely retarded in cutover areas. In Michigan, the effects of heavy browsing by moose threatened to eliminate paper birch from a timber stand *(Aldous 1947)*. In Ontario, severe moose and deer browsing occurred on yellow birch *(Wang 1968)*.

It seems likely that, as in the case of deer, high populations of moose will adversely affect the growth and establishment of seedling stands of birch. A density of 6 moose per square mile was tentatively considered to be satisfactory in good moose range in central Newfoundland *(Bergerud 1968)*.

SNOWSHOE HARE
(Lepus americanus)

Hares may damage seedlings by clipping the twigs, terminal shoot, or stem, or by gnawing the bark so that the stem is partially or completely girdled. In Newfoundland, paper birch was a preferred species in the diet of hares *(Dodds 1960)*. It was found that hares and moose competed for the same plants, and that serious competition between the two species probably occurs only in cutover areas where fir and birch are dominants. There was evidence, too, that a reduction in coniferous cover in cutover areas discouraged their use by hares in winter.

In general, hare damage to birch species may be presumed to be a rather common occurrence, but only because of the rather voluminous reports of hare damage to coniferous species that often grow in close association with the birches, and because there are reports of hare damage to planted birch *(Jarvis 1957, Stoeckeler 1955, von Althen 1964)* and to natural regeneration on research plots *(Wang 1968)*.

Small Mammals and Birds

Relatively little is known about the influence of small-animal feeding on yellow and paper birch. Reports of damage to tree seedlings and losses of seeds through the feeding activities of mice refer mostly to coniferous species, possibly because of greater past interest in problems of natural and artificial regeneration of these species. However, it may be indicative of the growing interest in regeneration of birch species that plantings of paper birch were reported to be damaged by the meadow vole *Microtus pennsylvanicus (Bjorkbom 1968, Stoeckeler 1955)*. Because these voles are widely distributed in the grassy field type, birch may be damaged when planted in this type. *Peromyscus* spp. very likely also feed on birch seeds, because they have a versatile diet and they also utilize the seeds of several hardwood species that grow in close association with the birches *(Hamilton 1939, Martin et al. 1951)*.

Red squirrels *Tamiasciurus hudsonicus* were found to inflict severe damage on paper birch in Alaska by girdling the trees *(Lutz 1956)*. And in New York they were reported to utilize yellow and paper birch seeds *(Hatt 1929)*. The junior author observed red squirrels collecting and storing the matured strobiles of yellow birch and also gnawing the bark of saplings of this species to obtain sap.

Studies and observations of feeding birds show that at least 8 species of songbirds eat the seeds of birch *(Curtis and Rushmore 1958, Gabrielson 1924, Martin et al. 1951, Saunders 1929, Silloway 1923)*. Grouse and rose-breasted grosbeaks feed on the buds *(Crichton 1963, Martin et al. 1951, McAtee 1908)*.

THE QUESTION OF CONTROL

The purpose of controlling animal damage is primarily to control economic damage. For example, if the stocking rate of birch seedlings is thought to be satisfactory despite losses of seedlings from mice, hare, and deer feeding, then economic damage has not occurred, so control is not necessary. If the effect of sapsucker and porcupine feeding in a sapling stand does not later reduce what is thought to be a satisfactory stocking rate, then technically, at least, there has been no damage. However, if porcupines later debark future crop trees, this is very clearly animal damage, and control may be warranted.

The point of this is that there may be a continuum of animal feeding on birch species—in this example, from mice to porcupines. But damage cannot be recognized as such until it is clear that the effect of an animal's feeding has lowered the yield or quality of wood in future crop trees. This may be determined easily after the crop trees have been selected, but it may be very difficult to determine in seedling stands.

The common practice in animal-damage control is to take direct action against the animal regardless of kind of damage or the stage of tree growth. It is direct action against the direct cause. And by the time damage has occurred it may well be the only practical alternative available for immediate damage control. But it is also rather short-sighted. It is analogous to fighting forest fires to prevent them. It bypasses all of the causal relationships in nature that led to the damage.

Only when the ecology or causal relationships that precede damage are better understood and controlled are we likely to achieve permanent and effective control. Such control should be possible through a planned program of habitat manipulation that maintains a balance between vegetation and animal populations, to permit coordinated production of both timber and wildlife.

LITERATURE CITED

Aldous, Shaler E.
1947. SOME FOREST-WILDLIFE PROBLEMS IN THE LAKE STATES. USDA Forest Serv. Lake States For. Exp. Sta. Sta. Paper 6, 11 pp. St. Paul, Minn.

Aldous, Shaler E.
1952. DEER BROWSE CLIPPING STUDY IN THE LAKE STATES REGION. J. Wildlife Manage. 16: 401-409.

Bergerud, Arthur T.
1968. MOOSE DAMAGE TO BALSAM FIR-WHITE BIRCH FORESTS IN CENTRAL NEWFOUNDLAND. J. Wildlife Manage. 32: 729-746.

Bjorkbom, John C.
1967. SEEDBED-PREPARATION METHODS FOR PAPER BIRCH. USDA Forest Serv. Res. Paper NE-79, 15 pp., illus. NE Forest Exp. Sta., Upper Darby, Pa.

Bjorkbom, John C.
1968. PLANTING PAPER BIRCH IN OLD FIELDS IN MAINE. USDA Forest Serv. Res. Paper NE-103, 12 pp. NE. Forest Exp. Sta., Upper Darby, Pa.

Blaisdell, James A., and Richard C. Hubbard.
1956. AN "OUTRIGGER" TYPE DEER FENCE. USDA Forest Serv. Calif. Forest and Range Exp. Sta. Forest Res. Note 108. 3 pp., illus.

Brander, Robert, and Forest W. Stearns.
1963. PORCUPINE WINTER FEEDING ACTIVITY IN MERCHANTABLE STANDS OF NORTHERN HARDWOOD-HEMLOCK. USDA Forest Serv. Res. Note LS-16, 2 pp. Lake States Forest Exp. Sta. St. Paul, Minn.

Crichton, V.
1963. AUTUMN AND WINTER FOODS OF THE SPRUCE GROUSE IN CENTRAL ONTARIO. J. Wildlife Manage. 27(4): 597.

Christ, John C.
1959. A STUDY OF YELLOW BIRCH *(Betula lutea)* IN THE BOGS OF ITASCA PARK, MINNESOTA. Amer. Midland Naturalist 61(2): 480-484.

Coulter, Malcolm W.
1959. WANDERER OF THE WOODLAND. Maine Fish and Game 1(2): 9-11.

Coulter, Malcolm W.
1966. ECOLOGY AND MANAGEMENT OF FISHERS IN MAINE. Ph.D. thesis, 196 pp. Syracuse Univ. (Dissertation Abstr. 27(9B), 1967.)

Curtis, Robert O., and F. M. Rushmore.
1958. SOME EFFECTS OF STAND DENSITY AND DEER BROWSING ON REPRODUCTION IN AN ADIRONDACK HARDWOOD STAND. J. Forestry 56 (2): 116-121.

Dodds, Donald G.
1960. FOOD COMPETITION AND RANGE RELATIONSHIP OF MOOSE AND SNOWSHOE HARES IN NEWFOUNDLAND. J. Wildlife Manage. 24(1): 52-60.

Dodge, Wendell E.
1959. AN EFFECTIVE POISON AND REPELLANT FOR PORCUPINE CONTROL. J. Forestry 57(5): 350-352.

Drinkwater, M. H.
1957. THE TOLERANT HARDWOOD FORESTS OF NORTHERN NOVA SCOTIA. Canada Dep. Forestry, Forest Res. Div. Tech. Note 57. 25 pp.

Eyre, F. H., and W. M. Zillgitt.
1953. PARTIAL CUTTINGS IN NORTHERN HARDWOODS OF THE LAKE STATES. U.S. Dep. Agr. Tech. Bull. 1076. 124 pp., illus.

Gabrielson, Ira N.
1924. FOOD HABITS OF SOME WINTER BIRD VISITANTS. U.S. Dep. Agr. Bull. 1249. 32 pp.

Gill, John D.
1957. REVIEW OF DEER YARD MANAGEMENT. Game Div. Bull. No. 5, 61 pp., illus. Maine Dep. Inland Fisheries and Game.

Graham, Samuel A.
1954. CHANGES IN NORTHERN MICHIGAN FORESTS FROM BROWSING BY DEER. N. Amer. Wildlife Conf. Trans. 19: 526-533.

Graham, Samuel A.
1958. RESULTS OF DEER EXCLOSURE EXPERIMENTS IN THE OTTAWA NATIONAL FOREST. N. Amer. Wildlife Conf. Trans. 23: 478-490.

Grisez, Ted J.
1959a. A LOW-COST DEER FENCE. J. Forestry 57 (1): 42-43, illus.

Grisez, Ted J.
1959b. THE HICKORY RUN DEER EXCLOSURE. USDA Forest Serv. NE. Forest Exp. Sta. Forest Res. Note 87, 4 pp., illus. Upper Darby, Pa.

Hamilton, W. J., Jr.
1939. AMERICAN MAMMALS. THEIR LIVES, HABITS, AND ECONOMIC RELATIONS. 434 pp., illus. McGraw-Hill Book Co., Inc., New York.

Hatt, Robert T.
1929. THE RED SQUIRREL: ITS LIFE HISTORY AND HABITS, WITH SPECIAL REFERENCE TO THE ADIRONDACKS OF NEW YORK AND THE HARVARD FOREST. Roosevelt Wildlife Ann. 2(1): 146 pp., illus. Roosevelt Wildlife Forest Exp. Sta., Syracuse Univ.

Hepting, George H., and George M. Jemison.
1958. FOREST PROTECTION. *In* TIMBER RESOURCES FOR AMERICA'S FUTURE. U.S. Dep. Agr. Forest Serv., Forest Resource Rep. 14: 185-220.

Hesselton, William T., C. W. Severinghaus, and John E. Tanck.
1965. POPULATION DYNAMICS OF DEER AT THE SENECA ARMY DEPOT. N.Y. Fish and Game J. 12(1): 17-30.

Hosley, Neil.
1956. MANAGEMENT OF THE WHITE-TAILED DEER IN ITS ENVIRONMENT. *In* THE DEER OF NORTH AMERICA. Walter P. Taylor, (ed.), pp. 187-259, illus. The Stackpole Co., Harrisburg, Pa., and The Wildlife Management Institute, Washington, D.C.

Howell, Thomas R.
1952. NATURAL HISTORY AND DIFFERENTATION IN THE YELLOW-BELLIED SAPSUCKER. Condor 54: 237-282.

Jacobs, Rodney D.
1965. SEASONAL HEIGHT GROWTH PATTERNS OF SUGAR MAPLE, YELLOW BIRCH, AND RED MAPLE SEEDLINGS IN UPPER MICHIGAN. USDA Forest Serv. Res. Note LS-57. 4 pp. Lake States Forest Exp. Sta., St. Paul, Minn.

Jarvis, J. M.
1957. CUTTING AND SEEDBED PREPARATION TO REGENERATE YELLOW BIRCH. Canada Dep. Forestry, Forest Res. Div. Tech. Note 53. 17 pp.

Jones, Milton B., and William M. Longhurst.
1958. OVERHANGING DEER FENCES. J. Wildlife Manage. 22(1): 325-326.

Jordan, J. S., D. Hagar, and W. M. Stiteler, Jr.
1965. DEER-BROWSE PRODUCTION AND TIMBER-STAND IMPROVEMENT IN NORTHERN HARDWOODS. N. Amer. Wildlife and Natur. Res. Conf. Trans. 30: 296-305.

Jordan, J. S., and Ward M. Sharp.
1967. SEEDING AND PLANTING HEMLOCK FOR RUFFED GROUSE COVER. USDA Forest Serv. Res. Paper NE-83, 17 pp., illus. NE. Forest Exp. Sta., Upper Darby, Pa.

Jorgensen, Richard N., and Sophie L. Lecznar.
1964. ANATOMY OF RING SHAKE ASSOCIATED WITH SAPSUCKER INJURY. USDA Forest Serv. Res. Paper NE-21, 9 pp., illus. NE. Forest Exp. Sta., Upper Darby, Pa.

Kilham, Lawrence.
1964. THE RELATIONS OF BREEDING YELLOW-BELLIED SAPSUCKERS TO WOUNDED BIRCHES AND OTHER TREES. Auk 81(4): 520-527, illus.

Krefting, Laurits W.
1951. CONSTRUCTION OF THE LAKE STATES DEER ENCLOSURE. USDA Forest Serv. Lake States Forest Exp. Sta. Tech. Note 361. 2 pp., illus. St. Paul, Minn.

Krefting, Laurits W., and C. J. Shiue.
1960. COUNTING DEER PELLET GROUPS WITH A MULTIPLE-RANDOM START SYSTEMATIC SAMPLE. Minn. Forestry Note 89, 2 pp. Univ. of Minn., St. Paul.

Krefting, Laurits W., J. H. Stoeckeler, B. H. Bradle, and W. D. Fitzwater.
1962. PORCUPINE TIMBER RELATIONSHIPS IN THE LAKE STATES. J. Forestry 60(5): 325-330.

Laramie, Henry A., Jr.
1968. DEER MANAGEMENT AND RECOMMENDATIONS IN NEW HAMPSHIRE. pp. 204-215. *In* THE WHITE-TAILED DEER OF NEW HAMPSHIRE. Hilbert R. Siegler, (ed.), N. H. Fish and Game Dep. Survey Rep. No. 10.

Longhurst, W. M., M. B. Jones, R. R. Parks, L. W. Neubauer, and M. W. Cummings.
1962. FENCES FOR CONTROLLING DEER DAMAGE. Calif. Agr. Exp. Sta. Ext. Serv. Cir. 514, 19 pp., illus. Univ. of Calif.

Lutz, H. J.
1956. DAMAGE TO PAPER BIRCH BY RED SQUIRRELS IN ALASKA. J. Forestry 54(1): 31-33.

Martin, A. C., H. S. Zim, and A. L. Nelson.
1951. AMERICAN WILDLIFE AND PLANTS. 500 pp., illus. McGraw-Hill Book Co., Inc., New York.

McAtee, W. L.
1908. FOOD HABITS OF THE GROSBEAKS. U.S. Dep. Agr. Bur. Biol. Survey Bull. 32, 92 pp., illus.

McAtee, H. L.
1911. WOODPECKERS IN RELATION TO TREES AND WOOD PRODUCTS. U.S. Dep. Agr. Bur. Biol. Survey Bull. 39, 99 pp., illus.

Olson, Herman F.
1966. RETURN OF A NATIVE. Wis. Conservationist Bull. 31(3): 22-23.

Pimlott, D. H.
1965. INFLUENCE OF DEER AND MOOSE ON BOREAL FOREST VEGETATION IN TWO AREAS OF EASTERN CANADA. Congr. Internatl. Union Game Biol. Trans. 6: 105-116.

Rushmore, Frances M.
1969. SAPSUCKER DAMAGE VARIES WITH TREE SPECIES AND SEASONS. USDA Forest Serv. Res. Paper NE-136, 19 pp., illus. NE. Forest Exp. Sta., Upper Darby, Pa.

Saunders, Aretas A.
1929. THE SUMMER BIRDS OF THE NORTHERN ADIRONDACK MOUNTAINS. Roosevelt Wildlife Bull. 5(3): 319-499, illus. Roosevelt Wildlife Forest Exp. Sta., Syracuse, N.Y.

Shaw, S. P., and W. M. Stiteler.
1962. WILDLIFE MANAGEMENT FIELD GUIDE. 10 pp. plus appendix. USDA Forest Serv., Upper Darby, Pa.

Shigo, Alex L.
1963. RING SHAKE ASSOCIATED WITH SAPSUCKER INJURY. USDA Forest Serv. Res. Paper NE-8, 10 pp., illus. NE. Forest Exp. Sta., Upper Darby, Pa.

Silloway, Perley M.
1923. RELATION OF SUMMER BIRDS TO THE WESTERN ADIRONDACK FOREST. Roosevelt Wildlife Bull. 1(4): 397-486, illus. Roosevelt Wildlife Forest Exp. Sta., Syracuse Univ.

Stiteler, William M., Jr., and Samuel P. Shaw.
1966. USE OF WOODY BROWSE BY WHITETAIL DEER IN HEAVILY FORESTED AREAS OF NORTHEASTERN UNITED STATES. N. Amer. Wildlife and Natur. Res. Conf. Trans. 31: 205-212.

Stoeckeler, J. H.
1950. PORCUPINE DAMAGE IN A NORTHERN HARDWOOD-HEMLOCK FOREST OF NORTHEASTERN WISCONSIN. USDA Forest Serv. Lake States Forest Exp. Sta. Tech. Note 326, 1 p. St. Paul, Minn.

Stoeckeler, J. H.
1955. DEER, MICE, AND HARES DAMAGE YOUNG ASPEN AND PAPER BIRCH PLANTINGS IN NORTHEASTERN WISCONSIN. USDA Forest Serv. Lake States Forest Exp. Sta. Tech. Note, 1 p. St. Paul, Minn.

Stoeckeler, J. H., R. O. Strothman, and L. W. Krefting.
1957. EFFECT OF DEER BROWSING ON REPRODUCTION IN THE NORTHERN HARDWOOD-HEMLOCK TYPE OF NORTHEASTERN WISCONSIN. J. Wildlife Manage. 21(1): 75-80.

von Althen, F. W.
1964. HARDWOOD PLANTING PROBLEMS AND POSSIBILITIES IN EASTERN CANADA. Canada Dep. Forestry, Forest Res. Br. Pub. 1043. 40 pp.

Wang, B. S. P.
1968. THE DEVELOPMENT OF YELLOW BIRCH REGENERATION ON SCARIFIED SITES. Canada Dep. Forestry and Rural Develop. Forestry Br. Dep. Pub. 1210. 14 pp.

■