THE RELATION OF MAMMALS TO THE HARVARD FOREST

By Robert T. Hatt*

Field Naturalist, Roosevelt Wild Life Forest Experiment Station, Syracuse, New York

CONTENTS

*Assistant Curator of Mammals, The American Museum of Natural History, New York City.

INTRODUCTION

Serious damage to the plantations of the Harvard Forest occasioned by feeding mammals had been noted in the winters of 1921 and subsequent years. This damage was brought to the writer's attention during the summer of 1925 when he was engaged in making a study of the red squirrel in the Harvard Forest. With the approval of Professor R. T. Fisher, Director of the Harvard Forest, and Dr. Charles C. Adams, at that time Director of the Roosevelt Wild Life Forest Experiment Station, the present study was undertaken. It was jointly supported by these two institutions.

Mr. Neil Hosley of the Harvard Forest, had previously made a thorough study of the damage done to the plantations by the red squirrels and obtained the most essential information in regard to this injury(Hosley, '25 and '28). His work is particularly valuable since it was possible for him to be in the field at the time the damage was being done, and to extend his observations over several years. The observations of the present writer were confined to the three summer months of one year.

The object of the present study was to ascertain what benefits to the plantations and natural growth forests of this area were attributable to the workings of mammals; to determine what factors were responsible for the loss occasioned by these animals and to suggest possible remedies for the local situation. This investigation was, however, not undertaken as a commercial inquiry but only as part of the policy of the Harvard Forest and the Roosevelt Station to further unbiased research into the problems of forest biology.

Camp was established on the south shore of Harvard Pond for the period from June 20 to September 12, 1925, and all field work was carried on with this camp as a base. Trips to North Ashburnham, Massachusetts, and State Line, New Hampshire, were made to investigate special conditions. During the summer of 1926, while studying the red squirrel in the Adirondacks and the Lake Champlain region many additional observations were made which proved the widespread nature of conditions noted at the Harvard Forest. At other times local conditions were investigated at Greenwich, Connecticut; Millbrook and Bedford, New York; and Englewood, New Jersey.

Because of the limited nature of the investigation little general collecting was carried on so that but scanty information can be given as to the vertebrate fauna of the Harvard Forest. No identifications are given unless the systematic status is beyond question. The

author alone is responsible for the identification of all animals and plants listed.

Five methods of inquiry were adopted, which listed in the order of their importance as to results are: observations on the flora showing evidence of mammal damage; interrogation of local residents; field observation on living animals; experimental feeding of captives; and examination of stomach contents of dead specimens. Of the first it may be said that the most important aspect was the examination of damaged plantations. Other methods were to examine forest trees for evidence, to examine the midden heaps of squirrels, and to search for stored or partly eaten foods of all mammals.

Only plantations of Scotch pine, Norway spruce, European larch and mixed conifers were examined, since the investigations of Mr. Hosley had shown other trees to be immune or negligibly damaged.

When the examination of an individual plantation was undertaken it was first roughly mapped, identified as to number and described. For most plantations, the area, age, planting distance, and height of the average tree was determined. In each case the description included a notation of the nature of adjacent habitats and their suitability for habitation by the mammals predatory upon these plantations. Floral composition, area, and ground conditions were considered.

If preliminary reconnaissance indicated that the damage to the plantation was not uniformly distributed a census of every tree, or alternate trees in alternate rows in the larger plantations, was made and the distribution of such damaged trees plotted in relation to adjacent habitats.

If, on the other hand, the damage was uniform (and this was usually the case as most plantations were small) no attempt was made to plot the distribution but only quantitative and qualitative conditions were noted. In very small plantations it was necessary to summarize the damage on every tree in order to obtain accuracy, but usually sufficient numbers could be obtained by surveying alternate rows, or sample rows at right angles to each other through the plantation.

In describing mouse damage, notes were taken to determine the percentage of trees injured and the percentage of these that died or that recovered.

In studying damage by porcupine, the percentage of trees injured was determined, the percentage completely girdled, the percentage partly girdled and the percentage killed in relation to each of these categories.

Red squirrel injury to larch was plotted in relation to the number with terminal buds clipped, the number with laterals clipped, and the amount of defoliation due to clipping of twigs.

Because of the cyclic growth habits of Scotch pine and Norway spruce and because of the squirrels' work on the terminal buds of branches it is possible to determine for a few years back in just which year the damage was accomplished. It was then determined what percentage of leaders was clipped each year, what percentage of the trees had laterals clipped each year, and, in case of Scotch pine, what percentage of laterals was clipped on a single sample tree for each of the three preceding winters.

Combining all these data the total damage to each plantation could be determined and an estimate made of the chances of survival in relation to mammal damage alone.

The influence of snowfall on the degree of annual damage could be determined in the case of Scotch pine and Norway spruce, if the hazardous assumption were made that the winter rodent population is at all times approximately uniform.

The relation of adjacent habitats to liability to damage, the foraging radius of squirrels, and the effect of size and age of the plantation on its susceptibility to depredations could all be determined in so far as the extent of the data justified the drawing of conclusions.

The author is deeply indebted to all who by their many courtesies and constant aid so greatly furthered the progress of the investigation. Professor R. T. Fisher, Mr. A. C. Cline, and Mr. Neil W. Hosley of the Harvard Forest went to unusual trouble in the establishment and breaking of camp, in furnishing transportation to distant areas, and in generally furthering the work at hand. Mr. Cline has kindly allowed the use here of four of his photographs (Figs. 195, 200, 208 and 209) which better showed tree damage than those taken by the writer.

Doctor Charles C. Adams was extraordinarily generous in the use of his time and energy in establishing the investigation and in seeing to the proper equipment of the field party. Mr. W. A. Dence of the Roosevelt Station always cared for the author's requests from the field with unfailing promptness.

Mr. and Mrs. Rupert Gast on many occasions courteously aided the author in many ways while the investigation was in progress.

THE HARVARD FOREST

The Harvard Forest occupies 2,068 acres in the town of Petersham, northern Worchester County, Massachusetts. The region is a highly glaciated peneplain, characterized by low ridges extending generally north and south. These ridges have a scanty soil covering their granitic cores, while in the valleys there is a deep rich soil which is, however, poorly adapted for agricultural purposes because of the abundance of glacial boulders near and on the surface.

The Petersham area was first settled about the year 1720. Within the next century the native forest had been reduced by clearing to about forty per cent of its former area. The bulk of the inhabitants remained on and near the ridges for protection from the Indians and because farming was easier there. The forests were then principally restricted to the lower-lying areas. The next half century, however, brought about a depopulation of the countryside because of the development of manufacturing along the larger streams, the drain on man power caused by the Civil War, and the opening up of the West, all of which made agriculture in the rocky soil unprofitable. The farms were abandoned, and this once thickly settled area was reduced to half its former population (Fisher, '21, p. 9).

The deserted farms rapidly reverted to nature's control, and trees again returned to the land. White pine seedlings gained root in the unplowed fields and nearly pure stands of this species appeared. Where there were no seed trees for white pine the areas grew up into gray birch, poplar, pin cherry and red maple. Broad-leaved trees gained the ascension in recently cut-over areas, regardless of the original stand.

The land for the Forest was obtained by Harvard University in 1907. Since then it has been under careful supervision. It is thus the oldest managed forest in the United States. The greater part of the area is naturally reforested though some seventy acres of plantation are established.

The aims of the management of the Forest as defined by the Director are to provide a model forest to demonstrate the practice of forestry, to maintain an experiment station for research in forestry, and to supply a field laboratory for students. These objects are admirably attained at this time.

With a considerable outlay in land and money devoted to plantations, it is important to know the relations of all forest animals to the trees, both as a means of determining policies for future guidance and as an aid in settling present unsatisfactory conditions. This paper is the result of but one of the many studies, made principally by entomologists, on the fauna of the Harvard Forest.

FOREST MAMMAL HABITATS

About three hundred acres in the Harvard Forest are occupied by grass land, swamps and ponds, while the balance is covered with natural forests and plantations. With the exception of a few negligibly small areas the grass lands are being allowed to revert to forest or are being planted.

In the Harvard Forest there are no remnants of the original stand. All are second growth types varying from seedlings to mature growth. Characteristic of northern New England, the forest is intermediate in make-up between the northern forests and the central hardwood area. No stands are perfectly pure in type, no one species growing in one locality to the exclusion of all others. Yet there are stands which are dominated by white pine, by hemlock, spruce, gray birch or mixed hardwoods. The bulk of the forested land is, however, covered with intermediate types.

For purposes of forest administration the stands of the Forest have been designated as follows: white pine; pine and transition hardwood; transition hardwood; hardwood swamp; gray birch; pine and gray birch; hemlock; pine, hemlock and transition hardwood; hemlock and transition hardwood; pine and hemlock; larch; and spruce. This classification, unless added to, subdivided, and qualified, would not suffice for use in vertebrate ecology, for the ever important undergrowth varies with the openness and age of the stand, the nature of soil conditions, and lastly, the nature of the surrounding habitats.

As a background for the present study it seems advisable to simplify: to describe the clearly marked types of forest characterized by the dominance of one species, or group of species, and to allow the reader to picture for himself the numerous intergrading conditions. Four principal forest types then present themselves. These are: white pine, red spruce, hemlock, and transition hardwood and white pine. No hardwood stands of sufficient purity to warrant the exclusion of white pine from their descriptive names were found. Gray birch areas while extensive are not considered since they are not permanent in nature, nor economically important enough to warrant recognition here. The nearest stand of virgin timber to the Harvard Forest is at State Line, New Hampshire. About two acres are covered with this old growth, the dominant trees of which are approximately one hundred and fifty years old. The ground slopes away from a sharp dry ridge, covered principally with pine, to a

sphagnum bog in which red spruce is dominant. On the intermediate land grow white pine, red spruce, hemlock and balsam. The pines are the largest of the trees and have grown to a magnificent height, with clear straight stems kept well pruned by the smaller moisture-retaining trees below the forest crown. Under-cover is sparse as little light reaches the forest floor.

White Pine Stand. Tom Swamp Block, Compartment VII, one-half acre, age sixty years: Bounded by lake border, white pine and gray birch; ground very wet, being but six inches above lake level.

Few trees other than white pine grow here, so few in fact that they would be overlooked by the casual observer. These species are: white oak (*Quercus alba*), red oak (*Quercus borealis*), wild red cherry (*Prunus pennsylvanica*), and red maple (*Acer rubrum*).

Shrubs and saplings though not numerous, form a high undergrowth. The following, in addition to seedlings of the trees listed above, constitute this stratum: hop hornbeam (*Ostrya virginiana*), chestnut (*Castanea dentata*), purple azalea (*Rhododendron nudiflorum*), high swamp blueberry (*Vaccinium corymbosum*), and wild raisin (*Viburnum cassinoides*).

The sparse low undergrowth was in late summer composed of the following plants: coral fungus (*Hydnum* sp.), royal fern (*Osmunda regalis,* var. *spectabilis*), cinnamon fern (*Osmunda cinnamomea*), common club moss (*Lycopodium clavatum*), ground pine (*Lycopodium obscurum* var. *dendroideum*), club moss (rare) (*Lycopodium sabinaefolium*), moccasin flower (*Cypripedium acaule*), rattlesnake plantain (*Epipactis repens* var. *ophioides*), bramble (*Rubus villosus*?), wintergreen (*Gaultheria procumbens*), late low blueberry (*Vaccinium vacillans*), star flower (*Trientalis americana*) and partridge berry (*Mitchella repens*).

A stand (Tom Swamp Block, Compartment VI, four acres, age fifty-five years; see Fig. 191) not as pure as the above, but situated on higher ground, is worth description, too, since it is more typical of other white pine stands in the forest. It is bounded by Harvard Pond and a roadway, on the other side of which is a mixed growth of pine, hemlock and transition hardwoods of ages up to twenty-five years.

The crown of foliage in this stand is formed by white pine from fifty to fifty-five years old and from fifty to sixty feet high. The second leaf story of young trees and saplings reach a height of fifteen to thirty feet. Six species of trees compose this

group: white pine (*Pinus Strobus*), gray birch (*Betula populifolia*), white oak (*Quercus alba*), red oak (*Quercus borealis*), wild red cherry (*Prunus pennsylvanica*) and red maple (*Acer rubrum*).

The undergrowth, three to fifteen feet high is composed of the saplings of the following trees and adult shrubs: white pine (*Pinus Strobus*), few; quaking aspen (*Populus tremuloides*), occasional; shag-bark hickory (*Carya ovata*), occasional; beaked hazelnut (*Corylus rostrata*), abundant; black birch (*Betula lenta*), common; chestnut (*Castanea dentata*), common; beech (*Fagus grandifolia*), occasional; white oak (*Quercus alba*), common; red oak (*Quercus borealis*), common; service berry (*Amelanchier canadensis*), common; black cherry (*Prunus serotina*), common; wild cherry (*Prunus pennsylvanica*), common; red maple (*Acer rubrum*); and high blueberry (*Vaccinium corymbosum*), common.

The ground growth, consisting of plants from those that truly hug the ground to others three feet high, is composed chiefly of the following species: Several unidentified mosses; common brake (*Pteris aquilina*); club moss (*Lycopodium clavatum*); false Solomon's seal (*Smilacina stellata*), abundant; false spikenard (*Smilacina racemosa*); Canada mayflower (*Maianthemum canadense*), abundant; moccasin flower (*Cypripedium acaule*); wild strawberry (*Fragaria virginiana*); running swamp blackberry (*Rubus hispidus*); wild sarsaparilla (*Aralia nudicaulis*), abundant; pipsissewa (*Chimaphila maculata*), abundant; shinleaf (*Pyrola elliptica*), abundant; greenish-flowered wintergreen (*Pyrola chlorantha*); Indian pipe (*Monotropa uniflora*), abundant; false beach-drops (*Monotropa Hypopitys*), abundant; aromatic wintergreen (*Gaultheria procumbens*), abundant; black huckleberry (*Gaylussacia baccata*), abundant; late low blueberry (*Vaccinium vacillans*), abundant; four-leaved loosestrife (*Lysimachia quadrifolia*); star flower (*Trientalis americana*), abundant; partridge berry (*Mitchella repens*), abundant; smooth aster (*Aster laevis*); sharp-leaved wood aster (*Aster acuminatus*); and seedlings of all trees previously listed.

Other plants occurring less commonly are: clintonia (*Clintonia borealis*), bunchberry (*Cornus canadensis*), mountain laurel (*Kalmia latifolia*), trailing arbutus (*Epigaea repens*), columbine (*Aquilegia canadensis*) and white baneberry (*Actaea alba*).

Transition Hardwood and White Pine Stand. Tom Swamp Block, Compartment I, three acres, age fifty years: Bounded by areas more mixed in character. Mature trees forming the crown are: white pine (*Pinus Strobus*), gray birch (*Betula populifolia*), American beach (*Fagus grandifolia*), white oak (*Quercus alba*), red

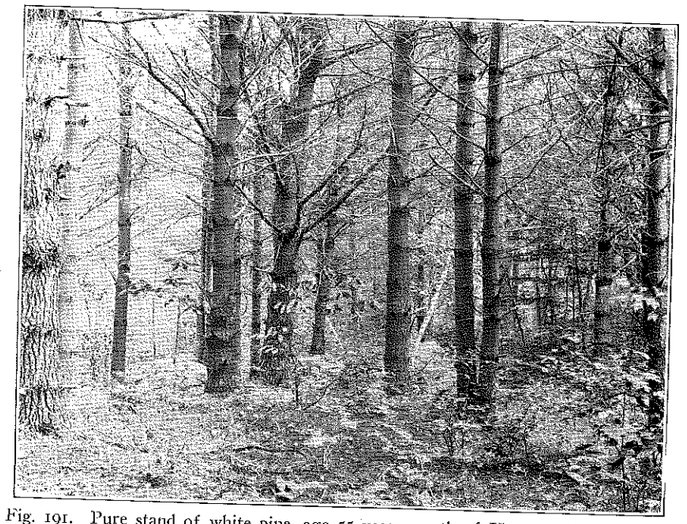

Fig. 191. Pure stand of white pine, age 55 years, south of Harvard Pond. The trees in the foreground have been artificially trimmed of their lower branches. August 10, 1925.

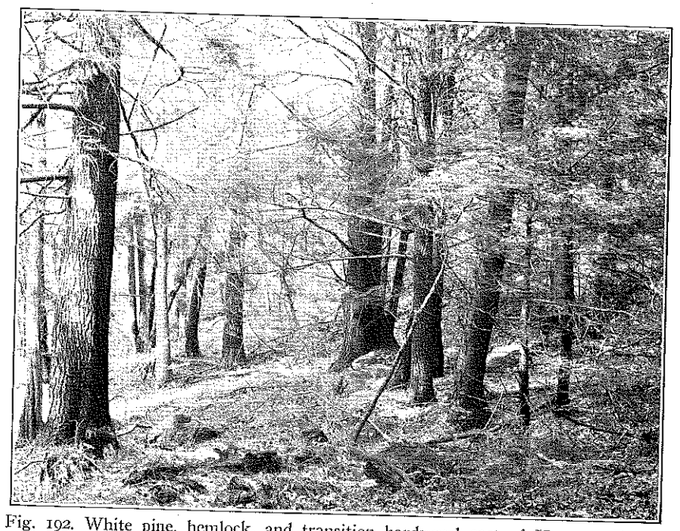

Fig. 192. White pine, hemlock, and transition hardwood east of Harvard Pond. August 10, 1925.

Fig. 193. Red spruce swamp, north of Tom Swamp. September 3, 1925.

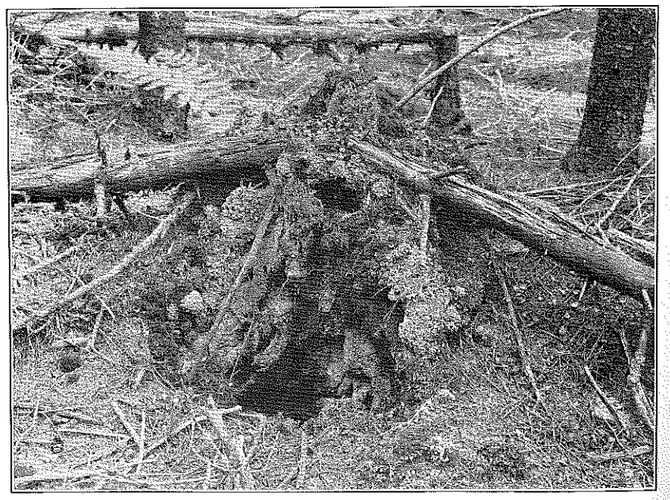

Fig. 194. Red squirrel midden of red spruce cones, typical of those common in the swamp shown in figure 193. September 3, 1925.

oak (*Quercus borealis*), black cherry (*Prunus serotina*), red maple (*Acer rubrum*), striped maple (*Acer pennsylvanicum*) and white ash (*Fraxinus americana*).

The undergrowth consists of seedlings of these trees, with the addition of the following trees and shrubs: beaked hazelnut (*Corylus rostrata*), chestnut (*Castanea dentata*), sassafras (*Sassafras variifolium*), high blueberry (*Vaccinium corymbosum*), witch-hazel (*Hamamelis virginiana*) and arrow-wood (*Viburnum acerifolium*).

The low herbaceous growth in late summer is characterized by the following species: maidenhair (*Adiantum capillus-Veneris*), sensitive fern (*Onoclea sensibilis*), false spikenard (*Smilacina racemosa*), false Solomon's seal (*Smilacina stellata*), wild bean (*Phaseolus polystachyus*), wild sarsaparilla (*Aralia nudicaulis*), shinleaf (*Pyrola americana*), aromatic wintergreen (*Gaultheria procumbens*), four-leaved loosestrife (*Lysimachia quadrifolia*), partridge berry (*Mitchella repens*), bog goldenrod (*Solidago uliginosa*) and sharp-leaved wood aster (*Aster acuminatus*).

Red Spruce Stand. Tom Swamp Block, Compartment VIII, Stand A, forty acres, age eighty years (Fig. 193): Bounded by leather-leaf bog, gray birch, pine and hemlock stands.

This spruce stand occupies a poorly drained swamp area to the north of Harvard Pond. A few glacial ridges break the level of its floor and in effect form islands. These ridges have been recently lumbered and burned over. The gravel ridges and the intermittent stream beds in the swamp form the only breaks in the dense stand of red spruce covering the area.

The spruce stand is about eighty years old though the trees have reached a general height of but thirty feet. The stand is very close and the tree tops form a dense canopy. Trees of a few other species are scattered through the spruce though their crowns cannot cover more than two per cent of the area. In a few small areas adjacent to the clearings larches are conspicuous, and here grow to a height of fifty feet or more. The trees found here are: white pine (*Pinus Strobus*), red spruce (*Picea rubra*), larch (*Larix laricina*), hemlock (*Tsuga canadensis*) and red maple (*Acer rubrum*).

In this stand there is no understory, but a thicket six to eight feet high occurs in a few open lanes that are the results of intermittent streams. The species composing this thicket are: reindeer "moss", Brussels carpet moss, sphagnum, cinnamon fern (*Osmunda cinnamomea*), clintonia (*Clintonia borealis*), painted trillium (*Trillium undulatum*), large blue flag (*Iris versicolor*).

goldthread (*Coptis trifolia*), pitcher plant (*Sarracenia purpurea*), sundew (*Drosera rotundifolia*), dalibarda (*Dalibarda repens*), wild sarsaparilla (*Aralia nudicaulis*), bunchberry (*Cornus canadensis*), Labrador tea (*Ledum groenlandicum*), pinxter flower (*Rhododendron nudiflorum*), aromatic wintergreen (*Gaultheria procumbens*), creeping snowberry (*Chiogenes hispidula*) and star flower (*Trientalis americana*).

Hemlock Stand. Tom Swamp Block, Compartment VII, one acre: Bounded by lake border; pine; and pine, hemlock and transition hardwood. The ground level of this stand is not more than four feet above the lake level, towards which it gently slopes.

The stand is practically pure hemlock. A very few scattered white pine (*Pinus Strobus*), paper birch (*Betula alba papyrifera*), and red maple (*Acer rubrum*) occur.

The ground cover is marked by the following species: common brake (*Pteris aquilina*), yew (*Taxus canadensis*), clintonia (*Clintonia borealis*), trillium (*Trillium* sp.), goldthread (*Coptis trifolia*), dalibarda (*Dalibarda repens*), wild sarsaparilla (*Aralia nudicaulis*), Indian pipe (*Monotropa uniflora*), purple azalea (*Rhododendron nudiflorum*), mountain laurel (*Kalmia latifolia*), aromatic wintergreen (*Gaultheria procumbens*), star flower (*Trientalis americana*) and sharp-leaved wood aster (*Aster acuminatus*).

Plantations. Plantations occupy some seventy acres of the Harvard Forest. Of these, thirty-two acres are in white pine. Red pine occupies fifteen acres; Scotch pine, three acres; western yellow pine, one acre; Norway spruce, seven acres; white spruce, five acres; and European larch, six acres. There is also an experimental acre containing alternate rows of white pine, Scotch pine, Douglas fir, Norway spruce and western yellow pine. With the exception of a few plantations laid out in white and red pines, all of these plantations are very small stands of three acres or less.

ANNOTATED LIST OF THE MAMMALS

The extensive wooded areas support an abundance of wild life, particularly in that section designated as the Tom Swamp Block, which has been set aside as a State Game Preserve.

The components of this fauna cannot be considered typical of the original for some of the larger forms have disappeared or become scarce through the encroachments of civilization, while other forms

such as the porcupine seem to have come in during recent years in response to changed conditions.

The twenty-seven species listed were taken, seen, or reliably reported. A few other forms probably occur but their inclusion here would invalidate the remainder of the list.

Parascalops breweri (Bachman). Hairy-tailed mole. Two specimens. This mole appeared to be common in the forests along the border of Harvard Pond. The specimens taken had drowned by falling into an open well that intercepted the course of a burrow.

The role in forest economy played by this animal probably lies principally in its insectivorous habits and in the continual overturn of soil by burrowing (Grinnell, '24, p. 843).

Sorex cinereus cinereus Kerr. Masked shrew. Two specimens. This shrew is common in the mixed stand forests. A female taken June 29 contained seven embryos with a crown-rump length of 11 mm.

Like the mole its value lies in its insectivorous habits and its extensive burrowing.

Blarina brevicauda talpoides (Gapper). Short-tailed shrew. Seen. Probably abundant, since conditions are favorable.

So far as known the short-tailed shrew occupies an ecologic niche similar to that of the long-tailed shrew.

Myotis lucifugus lucifugus (LeConte). Little brown bat. One specimen. Commonly seen. A captive, during one evening ate the following: one small dragon fly, several mosquitos, two deer flies, three house flies, and two moths. One of the moths was large, measuring about one inch long. At first the bat withdrew from it, but after a moment's delay seized the insect. The bat then hung by its thumbs from the top of the cage, grasped the wire of the side with its feet and by curling its interfemoral membrane and folding its wings so as completely to enclose the moth, proceeded leisurely to feed on the captive insect. Fifteen minutes later the bat dropped the sole remnants of the moth, its wings.

This and other species of bats occurring in the region without doubt play an important part in maintaining a balanced fauna and are of direct value in the destruction of insects harmful to the forest and annoying to man.

Euarctos americanus americanus (Pallas). Black bear. Reported to be a rare visitor. Bears at one time may have played a certain rôle in reducing the population of the deer (killing young fawns, probably) and of smaller mammals, as well as by the effect of its insectivorous habits and its probable dispersal of seed.

Procyon lotor lotor (Linnaeus). Raccoon. Two specimens examined. Tracks seen. Reported common. Little is known of the part the raccoon plays in the life of the forest. In the Petersham area it seems to be principally of interest as a fur-bearer.

Mustela noveboracensis noveboracensis Emmons. New York Weasel. One specimen. Reported abundant. Through its feeding on rodents and birds this carnivore, because of its abundance, is one of the major controlling factors in these populations.

Mustela vison subsp. (Schreber). Mink. Seen. Frequently taken by trappers. This is another species of importance in animal population control and in value to trappers.

Lutra canadensis canadensis (Schreber). Otter. Tracks, slides, dung, etc., seen. Reported a common visitor.

A young female otter was taken alive by William Baldwin, Jr., a local deputy game warden. He seized the otter as it was chasing chickens about their pen in his yard. Mr. Baldwin, who has also trapped many otter, has furnished the writer with many useful notes, partly from memory but mainly from notes written down during the seven months the otter was captive.

The largest otter Mr. Baldwin has taken, now in the Museum of Comparative Zoology, Harvard, weighed nineteen and one-half pounds. This was a very fat individual. Others taken ranged from fifteen to eighteen pounds. One whose dry skin measured fifty-seven inches from tip to tip was considered large by the fur dealers, yet came from an animal weighing but fourteen and one-half pounds.

According to Mr. Baldwin, two or three young are born at a time. They travel with the parents the first year. His captive, a female, was taken on July 5, and was, according to his description, very small, probably not more than one month old. The following January she measured thirty-one inches over all and had a body length of nineteen inches. Her weight at that time was eight and one-half pounds.

Mating behavior is a rough affair according to the manager of the fur farm that purchased the otter. He writes that "these animals never amount to much for breeding purposes if their teeth are gone. Mating with them is more or less of a fight and we have never had any success with any of the weasel family when the canine teeth were missing."

The summer pelage of the young otter was much lighter than the winter coat. Shedding began about October 10, the new coat appearing in patches until about November 15, when the winter pelage was complete.

The calls of this otter were several. One was a short, sharp whistle, such as is often used by people to call dogs. Another, Mr. Baldwin describes as a "cross between the yowl of a cat and a sharp rapid click of a rachet". A call used only when the animal was running was a low gutteral sound repeated rapidly, described best by a *Wunk-Wunk-Wunk-Wunk-Wunk*. Still another call was a sharp hissing bark of fear or anger, much like the similarly used bark of a fox. When hungry the otter would bark once and then repeat this at intervals of a few seconds.

Fish would be picked up from the tank in the enclosure, two or three at a dive, and would be held in the mouth. In feeding she would always hold the fish by its head, inserting one or two toes in the gills, and, starting at the tail, would eat the entire fish, scales, bones, and all. Rabbit and chicken, too, were eaten, though hair and feathers were not relished.

Progression on land was made by hopping movements, such as made by mink, interrupted by sliding whenever this was possible, even on level ground. The otter proved adept at climbing chicken mesh, and even in traveling on the underside of that which formed the roof of her enclosure.

Otter trails in the Petersham area are well worn and kept open the entire year. They form a circuit thirty to thirty-five miles long and are covered about every three weeks, according to Mr. Baldwin. Several trails were examined by the writer. These were only just wide enough for an otter to pass. They ran under low brush and over small logs. The trails always represented about the shortest route between two bodies of water, though in some cases, they would deviate to include a sharp declivity down which the otter might slide. Two of the three points of land in Harvard Pond had narrow low-lying bases. Across each of these the otters kept a partly open trail. The third peninsula was steeply arched and here the otters had five well marked slides which were shared with the muskrats. These five slides ended in the water, in contrast to a few others seen farther inland. Mr. Baldwin informs me that otter slides in snow are common in winter and usually do not end in water.

Fresh otter dung was found in the tracks. It was black, semi-fluid, and filled with fish scales and bones.

Mephitis nigra (Peale and Beauvois). Common skunk. Seen. A not uncommon resident. Skunks aid in mouse, bird and insect control and in all probability affect some plants directly through their feeding. The skunk is valuable, too, as a fur animal.

Vulpes fulva (Desmarest). Red fox. Droppings seen. Reported

common. The fox contributes to the forest life in the same way as most of the other carnivores.

Lynx rufus rufus (Schreber). Bobcat. Tracks seen. Reported as occasionally trapped. The bobcats together with the foxes probably help to control rabbits and other rodents.

Marmota monax preblorum Howell. Woodchuck. One specimen. Common in and near open areas. The stomach of a three-quarters grown young contained, besides much finely ground vegetable matter, the feathers, skin, and flesh of a nestling bird, mutilated beyond the possibility of identification, but presumably of a ground-nesting species. Through such occasional feeding habits as this, and its feeding on herbaceous growth, the woodchuck is an animal of economic importance, though usually not associated with the forests.

Tamias striatus lysteri (Richardson). Chipmunk. Trapped. Abundant in the Harvard Forest. Chipmunks were seen cutting and storing hazel nuts at the same time the red squirrels were likewise engaged. These rodents, while largely feeders on vegetation, also are insectivorous. Like the squirrels they hoard food supplies, but because these are usually placed in stone walls, stumps, and other places where seeds can not successfully grow, their beneficial effect is probably not so great as that of the squirrels.

Sciurus hudsonicus loquax Bangs. Red squirrel. Four specimens. Common. The author's notes on this species are incorporated in another publication (Hatt, '29). In general it may be said that the red squirrel plays perhaps the most important part of all the mammals of the forest in relation to the trees.

Sciurus carolinensis leucotis (Gapper). Gray squirrel. One specimen. Rare. This squirrel is reported to have been common in the past. Its disappearance seems to have been coupled with the extermination of the chestnut, and accompanied, not caused, by the ascendancy in numbers of red squirrels.

A female taken July 28 had mammae distributed as follows: thoracic 1–1; abdominal 1–1, and inguinal 2–2. They contained a small amount of milk.

Glaucomys volans volans (Linn.) and *Glaucomys sabrinus macrotis* (Mearns). Flying squirrels. Reported. It is probable that both species may occur within the Harvard Forest, though the reports received did not make any distinction. Flying squirrels in other areas have been found to feed on the bark of trees in winter and spring and to feed on many species of fruits and nuts. Also, they feed on insects, by which habit they may in some cases directly benefit the trees.

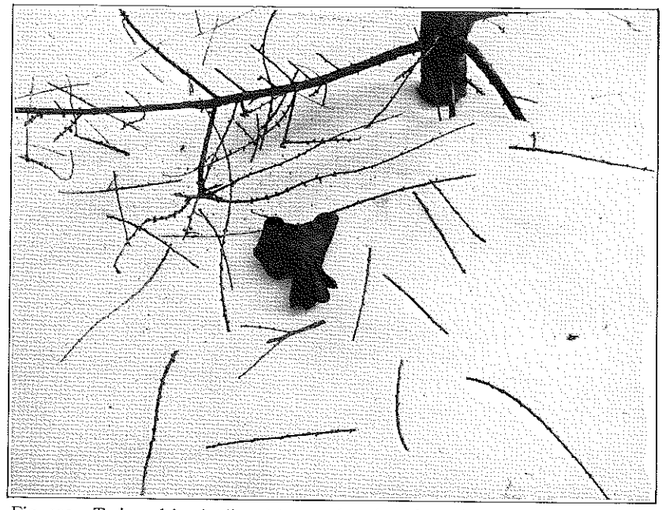

Fig. 195. Twigs of larch clipped by a red squirrel in a plantation in the Harvard Forest. Photograph by A. C. Cline.

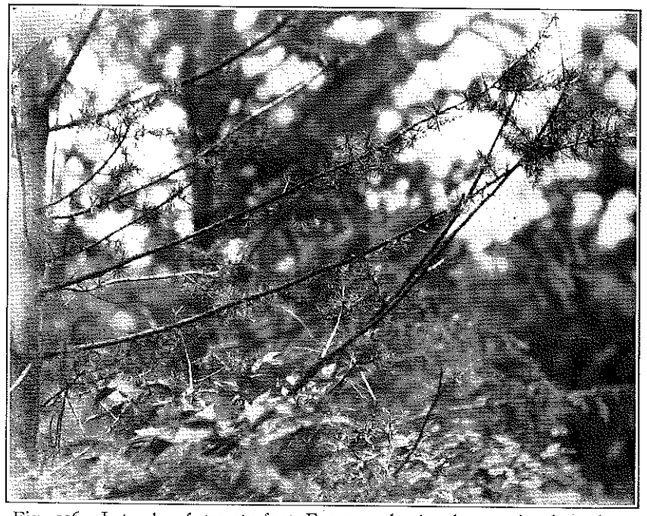

Fig. 196. Laterals of twenty-foot European larch whose twigs have been clipped by red squirrels in a previous winter. June 27, 1925.

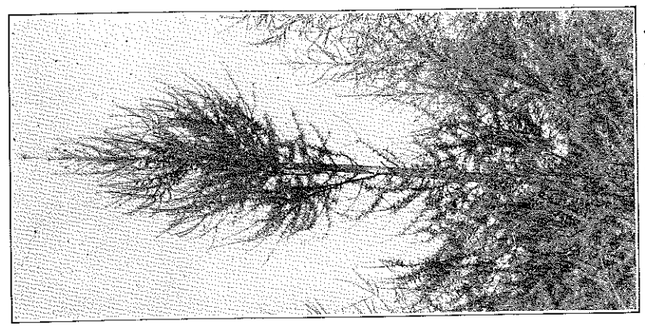

Fig. 199. Another larch showing typical red squirrel injury. August 25, 1925.

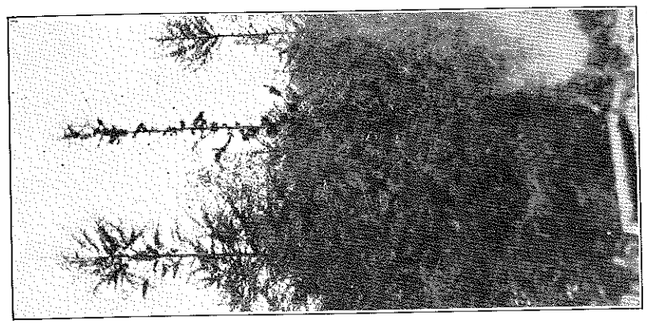

Fig. 198. A twenty-five-foot larch defoliated by red squirrels' winter-clipping of laterals. June 27, 1925.

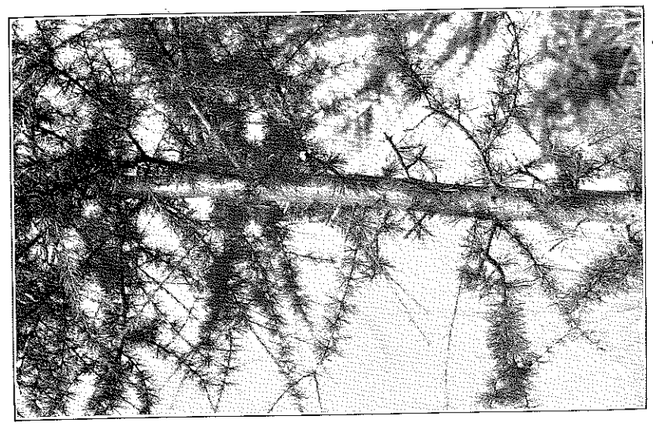

Fig. 197. The central part of a larch stem showing stumps of twigs winter-cut by red squirrels. August 25, 1925.

Peromyscus leucopus noveboracensis (Fischer). White-footed mouse. Four specimens. Abundant. A female taken July 1 contained four embryos of a 12-mm crown-rump length. Another taken August 31 contained six embryos measuring 6 mm from crown to rump.

A white-footed mouse was found clinging to the vertical trunk of a pine where it had been frightened by a dog. The mouse later ascended to the lowest limb, some fifteen feet above ground. Here it was seen at sunset, four hours later, apparently asleep.

An adult mouse of this species was introduced into a large cage with a pair of red squirrels. The mouse dodged the first savage lunge of one of the squirrels but afterwards disregarded their presence. After a week, the mouse, still alive and uninjured, was sharing the nest box with the captive squirrels.

Clethrionomys gapperi gapperi (Vigors). Red-backed mouse. Five specimens. Abundant. Many red-backed mice were taken in pine forest, red spruce swamp, and mixed forest. Two males and one female were taken in three successive nights in a trap set beside a log in a wet depression in the floor of a pine forest. Several other traps set on drier ground within a two-hundred-foot radius failed to catch a single mouse.

Captives were active sporadically throughout the day and night. One animal was trapped between eight-thirty and nine in the morning.

Mating behavior seems to be a matter of the male forcibly overcoming the female. Two captive males both tried to force a pregnant female newly entered in the cage. She strongly resisted both suitors and succeeded in breaking a leg of one of them as well as blinding him in one eye. This fight was maintained for about twenty-four hours, when the female gave birth to three young. For a day she was caged separately. The young having been killed, the mother was again caged with a single male, the one which she had badly injured. Immediately he attempted to catch her, but she dodged and fought. In the course of a few minutes, however, he was successful. Later in the day they settled down and built a nest which they shared peacefully.

A female taken September 3 contained embryos measuring 3 mm from crown to rump. Five were in the left uterine horn and one in the right.

A captive female gave birth to three young July 4. They measured 30 mm from crown to rump and 39 mm from tip of nose to tip of tail. Body length was 33 mm. The hind foot measured 6 mm. These mice were naked, blind, and but loosely enveloped in their skins.

Males were cannibalistic and killed the young immediately after birth. The mother tried valiantly but in vain to defend the young. When one male would attack her and try to force coitus, the other male would slip in, and, picking up one of the young, commence to eat it. One of these males hung on to a new-born young one so tenaciously that the writer with his fingers on the opposite end had to contest for its possession. When mother and young were removed to another cage she immediately constructed a nest and placed the young, already dead, within it.

The only sounds these mice were heard to make were series of high pitched squeaks that are best described as mouse-like. These were heard mostly when the mice were fighting.

Microtus pennsylvanicus pennsylvanicus (Ord). Meadow mouse. One specimen. Localities that should support a large population of *Microtus* are common in and near the forest. These small rodents are without doubt of considerable importance in their girdling of trees. Their field habitat and their almost strictly herbivorous habits keep them from playing any other part of importance in the forest.

Ondatra zibethica zibethica (Linnaeus). Muskrat. Two specimens. A common resident of the ponds and water courses. Five large embryos were taken from a female trapped July 22. The habits of this animal do not bring it in any direct relation with the forest trees, but it is of importance as a fur animal.

Mus musculus musculus Linnaeus. House mouse. One specimen taken. An established resident at many farms near the forest. One was taken in a pine forest bordering Harvard Pond, though in general it does not invade the forest.

Zapus hudsonius hudsonius (Zimmermann). Jumping mouse. One specimen. It is not known how abundant this mouse is locally nor what its relations to the forest are.

Erethizon dorsatum dorsatum (Linnaeus). Porcupine. Skeleton, sign, etc., seen. Professor R. T. Fisher stated that he had never heard of porcupines in the region until late years and believes that they have invaded the area recently. He also quotes an old hunter of some forty years residence as saying that there were no porcupines near Petersham until a few years ago.

It appears that the only relation of the porcupine to the forest lies in its browsing on trees and occasionally girdling them.

Lepus americanus virginianus (Harlan). Snowshoe hare. One specimen. Reported common. No evidence of damage to trees was seen, though it is reasonable to expect that it feeds at times on the seedlings of trees, and barks the smaller ones during the winter and spring.

Sylvilagus transitionalis (Bangs). Cottontail. Seen. A half-grown cottontail was seen habitually to feed in the roadway near camp. This animal was coprophagous, which suggested that this habit might aid in explaining the abundance of rabbits in roadways. Their relations to the trees are probably much the same as those of the hare.

Odocoileus virginianus borealis (Miller). White-tail deer. Seen. Trails common. Early one morning a doe, with her twin three-quarters-grown fawns, was jumped on a small island three hundred yards from shore in Harvard Pond. The doe took to water and was followed by the fawns. Half swimming, half walking over the soft bottom, the family soon reached the nearest shore and disappeared. The animals were known not to have been on the island at a late hour the evening previous.

Deer were feeding on brake ferns early in July, stripping the leaves from the fibrous stem. Many seedlings were found in the forests, that appeared to have been stripped of their leaves by browsing deer. It is likely that deer may be responsible for a high mortality among seedlings.

RELATION OF INJURIOUS MAMMALS TO IMPORTANT SPECIES OF TREES

Red Squirrel Damage to European Larch. The red squirrel injures larch by clipping off many slender twigs, from which it later eats the buds. The twigs, from six to twelve inches long, are cut close to the trunks (Fig. 197). Usually the clipping of twigs from the main stem is more or less limited to a zone midway up the trunk (Fig. 199), though in more severe cases it may extend the length of the stem and reduce the tree to a nearly bare pole (Fig. 198). A tree with a belted or irregular contour invariably shows numerous short stubs of twigs along the trunk (Fig. 197) and a mat of cut twigs at the base.

After the twig has been cut the squirrel hollows out the buds along its margin and at the tip and then drops the twig to the snow below (Fig. 195). Only rarely are leaders cut, so stems are almost always desirably straight. Red squirrels have not been actually observed doing this injury, but no other local animal would be capable of performing the work in quite the same manner. Almost conclusive evidence lies in a comparison made between some freshly clipped and budded twigs gathered from a plantation after a heavy snow

(mailed to the writer by Mr. Hosley) and some similar twigs budded by a pair of captive red squirrels at the same time. Not the slightest difference was seen between the two. As added evidence the marks of teeth on freshly clipped twigs fit exactly the incisors of a red squirrel.

Injury by twig-cutting is produced during periods of heavy snowfall. A second cycle of damage occurs in the spring when the buds show first signs of growth (Hosley, '28, p. 46), but at this season the buds only are removed, the twigs being left untouched.

In only two plantations do trees appear to be seriously affected by the cuttings, for the foliage area in other stands is not reduced by more than one-quarter, and this loss is somewhat compensated by the subsequent development of many short twigs bearing dense leaf clusters. The two exceptions (Prospect Hill Block VII v. and w.) have many trees with twenty-five to ninety per cent of their leaf-bearing twigs cut. Here growth must be considerably hampered. Not only are individual trees more badly affected in these plantings but the percentage of trees damaged is much higher.

All the larch plantations are very small, none being more than one and one-half acres in extent. While they do not in themselves support a resident squirrel population, any part of any plantation is easily within reach of the squirrels, since each plantation is bordered on at least one side by a natural stand of mature white pine. All plantations show squirrel damage fairly evenly distributed throughout, as might be expected since the edge of any plantation furthest from the natural forest is within easy traveling distance for a red squirrel.

Red Squirrel Damage to Scotch Pine. The leaders and branches of Scotch pine are stout and offer a good footing to a red squirrel. Probably because of this and the inconvenience of cutting through such a heavy stem, the squirrel cuts off the winter buds at their bases. The inner green tissues are eaten and the large papery husks are dropped to the snow below. A large cluster of buds caps the leader. In most cases each one of these is destroyed and the tree has no method of continuing its growth in height until a new set of buds is formed below the injured whorl. With the coming of the growing season these new buds send forth their shoots at a nearly equal rate, so that instead of a straight leader with a well formed ring of laterals below, there is developed a group of competing branchlets which form a "broom" (Figs. 202 and 203) at the crown of the tree. The annual repetition of such injury together

with similar injury to the buds on branches below the leader results in a growth resembling a bush (Fig. 200) more than a well formed tree (Fig. 201).

A red squirrel has been seen in the act of feeding on the winter buds of Scotch pine (Hosley, '25, p. 455). Examination of the injury revealed conditions identical with those found throughout the plantations. The squirrel traveled through the trees and in consequence left no tracks on the ground below.

Some workers in the Harvard Forest who have observed the injury only in the summer were of the belief that much of the damage might have been due to alternate thawing and freezing in the spring. It was stated by one that a Scotch pine plantation near Syracuse, New York, showed similar bud damage but that there were no squirrels at all in the vicinity. While the writer is not well acquainted with local conditions near Syracuse, it is known that there are red squirrels throughout that region, and it seems more probable that their presence had escaped notice. It is not impossible of course that some other species of squirrel or other rodent was responsible in this instance.

Frost damage to Scotch pine in Europe has been described by Hartig ('95). There it affected chiefly two- to six-year plants (an age group unaffected by squirrels at Petersham) and produced a clinical picture very different from that shown in the Harvard Forest.

No bud injury whatsoever was found in plantations examined through Bronx, Westchester, Dutchess and Essex counties, New York, and in northern New Jersey and southern Connecticut.

Eighty-eight per cent of the Scotch pine at North Ashburnham, Massachusetts, had been deformed by terminal bud injury done by red squirrels. Twenty-eight per cent of all trees had the leader killed but once. Forty-two per cent were twice injured. Twelve per cent had been clipped three times, five per cent four times, and one per cent five times. Injury is still continuing.

The effect produced on a single tree is suggested by a census taken on a typically injured tree on the Harvard Forest. The terminal buds of twenty-eight of a possible eighty-three laterals were removed during the winter of 1924–1925. Twenty-five of a possible seventy-nine were cut the winter previous. This work, however, while producing a tree unsymmetrical and ragged in outline, does not affect the growth or straightness of the main stem. On the contrary, leaf surface seems to be increased because of the numerous adventitious shoots that are produced about the budded stems and the total metabolism for the year is probably greater than before.

Injury is greatest in winters of heaviest snowfall. The writer's data bearing this out were obtained from a single plantation count of damaged leaders and gives figures less striking than those of Hosley who carried his census over five plantations. Damage in the winter of 1922 was fifty-six per cent. The following winter, one of greater than average snowfall, damage was eighty per cent (Hosley, 93.2%). The winter of 1924–1925, with less than average snowfall, had injury reduced to seventy-two per cent (Hosley, 53.6%). Snowfall during the winter 1925–1926 was heavier than in the preceding winter, and, judging by a letter from Mr. Hosley, the injury produced at that time was more extensive than that of the year previous.

Red Squirrel Damage to Norway Spruce. Red squirrel injury to spruce is, as in the case of Scotch pine, primarily the result of trunk distortion rather than defoliation. The terminal bud, which is well protected from above by a cluster of sharp needles, is usually cleaned out from the base, leaving a hollow, normal looking bud sheath. If the bud is not destroyed *in situ* the squirrel may cut off the terminal or a lateral cluster from one to four inches back from the tip (Fig. 206), and carrying it to a secure resting place in the same tree will proceed to feed upon the buds. The most frequently budded points are the leaders and the tips of the first whorl below the leader (Figs. 204 and 205). The tree is saved from serious deformation by the vigorous perpendicular growth of one or more shoots from uninjured buds or branches below the old leader. Occasionally when more than one leader is thus produced (Fig. 207) the competitive growth is wasteful of the energy of the tree. Bending of the main stem of the tree due to the development of a new leader from a lateral bud is not permanent, for the change in angle is not great and disappears with the annual increment in girth.

Squirrels have not actually been observed pilfering the plantations of spruce, but, for the same reasons that it is certain that red squirrels are guilty of larch injury, it is certain that such damage to spruce is to be credited to them also. But unless a definite clipping by sharp teeth is observed it is not fair to accuse the red squirrel for each deviation from straight growth of a trunk, for there are at least two other agencies which cause the suppression of the leader. The first of these is the failure of the terminal bud to germinate; the second, the killing of the leader by the white pine weevil. After about three seasons it would ordinarily be impossible to ascertain which of these caused the damage. Often in case of fracture the

Fig. 200. Scotch pine plantation on the Harvard Forest showing the bushy growth resulting from repeated red squirrel injury. Photograph by A. C. Cline.

Fig. 201. Scotch pine plantation near Speculator, New York, showing no mammal damage. Contrast the straight regular growth here seen with the deformed trees figured above. June 24, 1926.

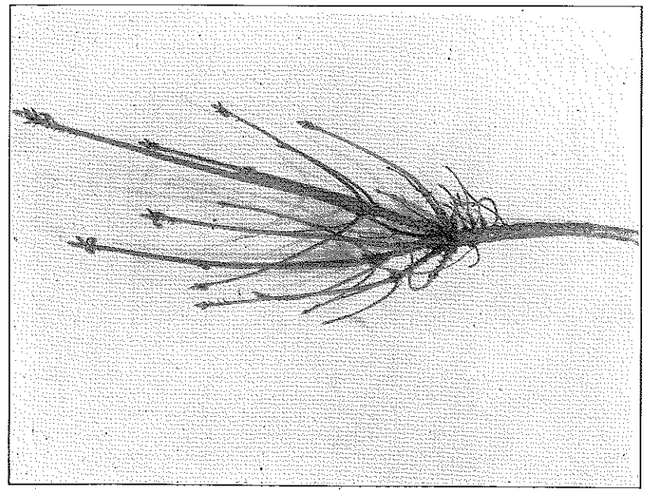

Fig. 203. The same "broom" shown in figure 202, with the foliage removed. September 12, 1925.

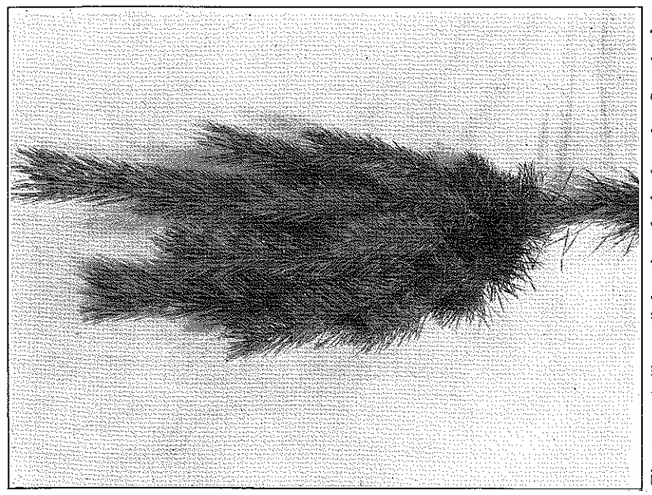

Fig. 202. A "broom" forming the leader of a Scotch pine. This competitive growth of many laterals is due to the destruction of winter buds by red squirrels. September 10, 1925.

evidence may be wiped out before examination. Laterals, too, may fail to have the terminal bud germinate, and deviate from their straight course. Some unknown agency occasionally breaks (not cuts off) a tip, but this is infrequent. To be certain that a squirrel hollowed out a terminal bud it should be examined no later than the ensuing spring.

Damage is most severe during the periods of heavy snowfall, as in the case of Scotch pine, according to Mr. Hosley.

Four plantations of Norway spruce occur in the Forest. Of these only two have been injured. The most severely damaged plantation was a fifth-acre stand of ten-foot trees. Here no tree escaped injury. A four-acre tract of trees from ten to twelve feet high showed extensive though uniform damage. The distribution of injury is clearly correlated with the character of the adjacent habitats. To the south a fifteen-acre open heath, blanketed by a dense growth of spiraea, raspberry, blackberry, blueberry, sweet fern and grasses, supports no squirrels. To the west a broad belt is planted to young Norway spruce and white pine. No squirrels would invade from this quarter. To the north a stone fence separates the plantation from several acres of pasture which supports a scattered growth of mature white pine. Possibly a pair (or more) of squirrels lives in these trees and forages on the plantation. To the northeast is a plantation of nine-foot white pine, not a habitat of red squirrels. From the east must come the bulk of the invaders. Here is a natural growth of twenty-five-foot white pine containing a sprinkling of hardwoods. While this stand supports red squirrels it does not appear old enough to furnish an abundance of food. Injury to the plantation proves most severe, as might be expected, on the eastern and northern borders. The squirrels appear to invade from the forest directly and by way of the stone wall. Damage diminishes toward the south to the last twenty rows which are practically untouched. In contrast, the northernmost twenty rows show scarcely a tree that has escaped.

Adjacent to this plantation is a stand of five-year-old Norway spruce which is as yet undamaged, seemingly because of the small size of the trees.

No trace of damage occurred in the fourth plantation. This was a stand of about one acre of ten-foot trees. The reason for its escape from squirrel depredations appears, as was first suggested by Mr. Hosley, to be due to the age and extent of the forest bordering the plantation. The stand was mixed growth from seventy to one hundred years old. Large quantities of cones and nuts are available over an extensive area and it seems practically conclusive that

here alone the squirrels are able to find and store sufficient winter foods; and furthermore here alone is the forest old enough and extensive enough to contain in fullest numbers the natural enemies of the red squirrel.

The effect of heavy snowfall on the amount of injury is borne out by the figures of Hosley, and my own, also, though Hosley's figures ('28, p. 46) show almost six times as much damage to the same plantation as do mine. Mr. Hosley's census was taken in winter, when damage was fresh and cuttings could be seen on the snow. He obtained his percentages by a row count of one hundred trees, while mine, taken in summer when damage was not so evident, were obtained by examining every other tree in every other row. One-fourth of the trees in the plantation were therefore examined, and the entire area was represented. Presumably Mr. Hosley saw the damage more clearly than I, but did not obtain representative figures because of the method of counting. It is probable that the true percentage lies somewhere between Hosley's figures and mine.

The winter of 1924–1925, a year of light snowfall, was accompanied by four per cent injury in this plantation. The winter previous, a season of heavy snowfall, was marked by thirteen per cent of the trees being cut. The winters of 1922–1923 and 1921–1922 showed nine per cent and four per cent injury respectively.

Porcupine Damage to Larch. The porcupine has found European larch to its liking and in winter has invaded the plantations of this species and taken its toll of trees. All injury is done in winter or early spring. To appearances most of it is done from the surface of the snow, or while the animal sits on the lower branches. Due probably to the small size of the larches, the injury is confined principally to the main stem (Fig. 208), from which the rodent eats the bark.

If the tree is but partly girdled, it lives on. When completely girdled two feet or so from the base, all the tree above this banding dies, while below it the branches will retain their vitality. If the tree is completely encirled at the base it usually dies. A single exception to this was found. Here the tree was completely girdled for ten inches along the stem. The tree at this point was three inches in diameter.

Four of six plantations showed porcupine injury. Those which had escaped were the two smallest. In each of the other four, damage was concentrated in a small group of trees along a border adjacent to mature forest, though individual trees scattered through the plantation showed injury. The porcupine is not overfond of roving and seems content to settle itself in a small group of trees.

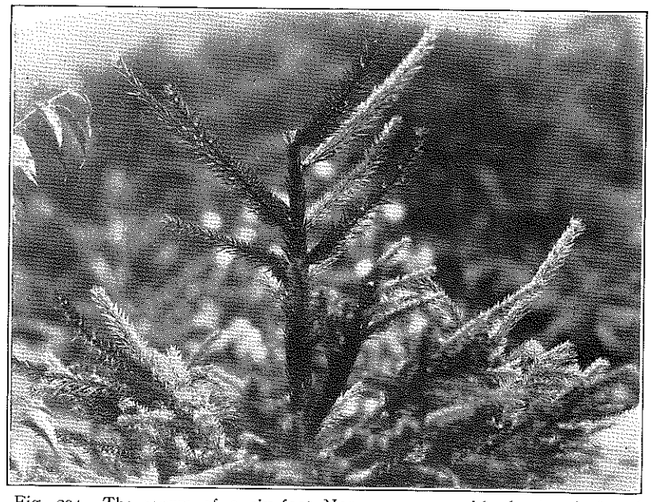

Fig. 204. The crown of a six-foot Norway spruce with the terminal and lateral twigs cut by red squirrels the winter previous. June 27, 1925.

Fig. 205. The crown of a five-foot white spruce on Valcour Island, Lake Champlain, New York, with the leader cut by red squirrels. August 26, 1926.

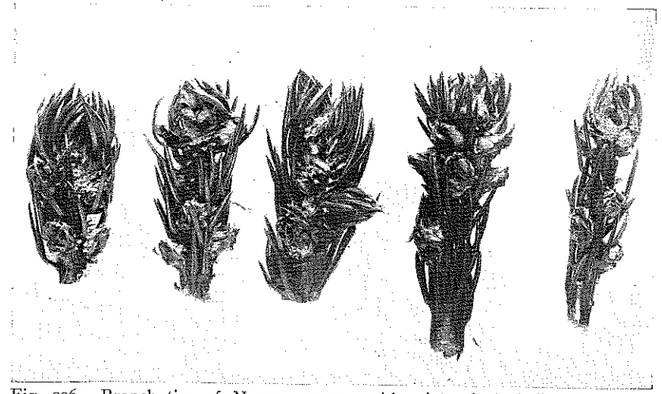

Fig. 206. Branch tips of Norway spruce with winter buds hollowed out by red squirrels. January, 1926

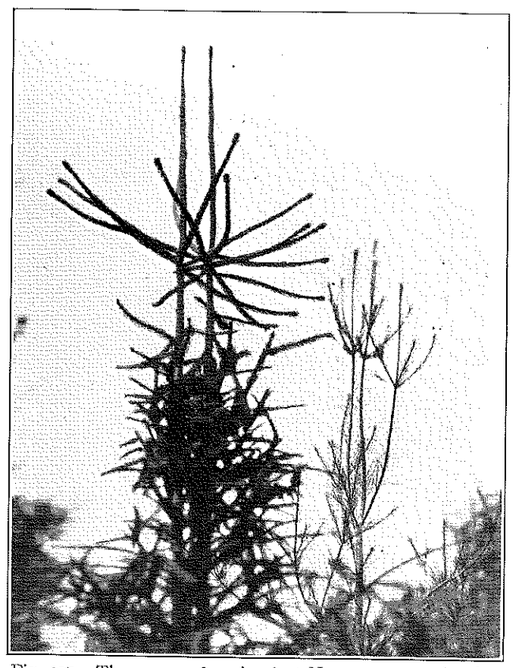

Fig. 207. The crown of a nine-foot Norway spruce showing twinning of leaders apparently caused by red squirrel clipping a leader in a previous winter. June 27, 1925.

The plantation showing the heaviest proportion of trees injured or killed by porcupine had twenty-two per cent of the trees affected. Five-eighths of these were killed. The second most serious case showed twenty per cent of the trees girdled. Three-fourths of these resulted in deaths. A third plantation had but nine per cent of its trees touched. Of these, also, three-fourths were killed. The remaining damaged plantation had trees barked to the extent of seven per cent of the total. Approximately three-fourths of these had died.

Compared with the red squirrel, the porcupine does not cause such extensive damage to larch plantations, though where it does attack its work is far more thorough.

Porcupine Damage to Scotch Pine. Scotch pine plantations of the Harvard Forest have not as yet been damaged by porcupines. At North Ashburnham, Massachusetts, there is, however, a privately owned plantation which demonstrated clearly what is to be expected in the Petersham area when conditions are adverse. The only environmental difference the writer could detect between the locality of the injured plantation and that of the uninjured was that the Scotch pine plantations in the Harvard Forest, where they were near porcupine-infested areas, were also close to larch plantations. In these larch plantations the porcupines foraged evidently preferring them to those of Scotch pine. Hemlock, an important porcupine food tree, is common near plantations in both areas.

The porcupines girdle these pines as in the case of other trees. They stand or sit on the ground, snow or a low branch and eat until all the bark within reach is consumed, or until they are otherwise prompted to move. The bark is removed to the wood, so that complete girdling results in the ultimate death of the tree.

No porcupines were in the plantation the middle of July, though some of the damage was not more than a month old. The animals probably feed here throughout most of the year.

A representative census of two hundred trees in the plantation showed thirty-two per cent damaged, while of these but ten per cent were dead, or about three per cent of those in the plantation. The stand, which covers nearly three acres, was planted about 1910.

Porcupine Damage to Hemlock. Porcupines commonly feed on the bark of hemlock, but in only two trees, growing close to each other, was the damage seen to be extensive. It has been previously stated that the advent of the porcupine into this region is quite recent. It may be for this reason that damage has not become serious throughout the forest.

The two trees noted (Fig. 209) grew in a narrow strip of white pine separating two larch plantations. Several larch trees adjacent to these hemlocks had been girdled and killed by porcupines. At the foot of the hemlocks there were several dens in the rocks, which to all appearances had served as habitations for the one or more porcupines which did this damage. It appeared as though this small circle had been chosen as a feeding ground for a long winter, the time probably having been divided between the den and trees within a radius of fifty feet. The injury was perhaps three years old at the time of examination.

The hemlocks were each about twenty-five feet high. The porcupines had not girdled the trunk but had gone out on each branch to a point where it was one-half to three-quarters of an inch thick, and here cut the tip off. Along the branch to this point all lateral twigs had been cut, too, except such as were too large. From many of these main branches some bark had also been removed.

Since the time of damage, small twigs have developed from most of the laterals and in places these form tufts of green foliage which from a distance resemble large beads strung at intervals along the branches. Obviously such complete damage to the tree limits its future growth to such an extent that it becomes commercially and æsthetically valueless.

Microtine Damage to Scotch Pine. Damage to one plantation of Scotch pine in the Harvard Forest and to one near North Ashburnham, Massachusetts, is characteristically microtine, though it could not be determined positively which species had been at work as three microtines probably occur in this area—the meadow mouse (*Microtus p. pennsylvanicus*), the red-backed mouse (*Clethrionomys g. gapperi*) and the short-tailed vole or bog-lemming, (*Synaptomys cooperi*). The habitats bordering the damaged plantation in the Harvard Forest are more favorable to *Clethrionomys* than to *Microtus* and it is the writer's belief that the first of these was responsible for the girdling.

The Harvard plantation showed complete girdling of practically all trees that were injured. It would appear that the mice conserved energy in removing the outer bark by feeding on one tree until all within reach had been utilized. At North Ashburnham girdling was complete in only about twenty-five per cent of the cases. The denuded belt extended from the ground to a height of six to twelve inches. Inward, it continued through the cambium.

The individual tree is damaged in ratio to the amount of girdling. An incompletely girdled tree does not die, but a swelling is produced in the side opposite the injury, by means of which the food and water supply are maintained to the parts above the injury. Since the bark does not regenerate over the place of injury the tree is destined to die before maturity, provided the injury extends over more than one-half the circumference of the tree. This is because of the resulting weakness of the base. The immediate effect produced is a marked stunting of growth, most severe the first season following injury and diminishing in subsequent seasons.

If girdling is complete the tree usually dies within a few months. In a small percentage of the cases, however, the tree forms a huge swelling above the denuded ring and the transpiration stream is apparently reestablished in the deeper-lying layers (Fig. 210). Such trees do poorly and in most cases die within three years, though a few in the Harvard Forest are still alive eight years after the injury. These trees appear, however, to be now very near death. The weakened non-growing base eventually will determine their fate even though physiologically the trees are able to maintain life. A few other trees that have been girdled slightly above the base have sent all their growth into one of the laterals below the band of girdling. This lateral then turns at a right angle to its former plane and parallels the old dead trunk (Fig. 211). The tree, thus making a last abortive attempt to live even though against the probability that it will be able to establish itself firmly enough by roots to support the new trunk, has lost as many years competitive growth as represented by its age when the mice attacked it. Its one hope is in an already well established root system.

The Harvard Forest plantation was girdled to about fifty-one per cent of its total, twenty-one per cent of all the trees being killed from this cause. The North Ashburnham plantation was fifty-nine per cent girdled, half of this number being killed. The trees in the first case were eight years old at the time of injury. The others were apparently but six years old.

In each plantation injury was local in distribution, adjacent trees being affected rather than scattered trees throughout the stand (Fig. 212). In one of these, eighty-three adjacent trees were killed while approximately an equal number were scattered among the living.

Two other Scotch pine plantations in the Harvard Forest, each about one mile from the one damaged, and approximately of the same age, showed no injury.

Injury to the trees of the Harvard Forest was done in the winter of 1917–1918, though there are no records as to the month or the duration of the activity. The owners of the North Ashburnham

plantation state that the injury there was accomplished about 1916. It is probable that the voles in the years of attack on Scotch pine were in a period of over-population and that crowding caused them to draw upon food resources not ordinarily utilized. The fact that mouse damage was not repeated each winter has given the plantation some chance of continued growth. The mice girdled the Harvard trees during a period of heavy snowfall, and judging from the level of the injury, worked from tunnels in the snow. Mouse girdling of Scotch pine is apparently not uncommon in the eastern United States. The writer has observed similar injury near Katonah, New York, and Greenwich, Connecticut. Silver ('24, p. 5) cites a case in New York of complete girdling of one thousand six-year-old Scotch pines in a five-acre block. This he attributes to *Microtus*. Plantations at South Mountain Park, New Jersey, and at Millbrook and Saranac lakes, New York, showed no injury.

Deer Damage to Ash. During the winter and spring months deer feed on the terminal shoots of ash in young second growth stands in clearings. They clip off branches a half-inch in diameter, and while this does not kill the tree it greatly retards growth, and when thoroughly done produces a bushy growth rather than a straight tree. The damage is general in the forest as the deer are wide-ranging, but is most noticeable in the clearings between Petersham village and Harvard Pond. Such damage does not lend itself to statistical analysis and the extent of damage cannot be easily computed. It is not so serious a matter as the killing of trees in plantations, for there has been no monetary outlay in planting; nor is the entire tree growth destroyed, for numerous seedlings of other species stand ready to take the places of the trees that fail.

FOREST RELATIONS OF THE PRINCIPAL DESTRUCTIVE MAMMALS

Red Squirrels. Squirrel injury to trees in the Harvard Forest is practically limited to the harmful effects of their feeding on larch, Scotch pine and Norway spruce during periods of heavy snowfall. Their attack on larch does not deform the trees, but continued feeding produces defoliation which must seriously retard the growth. Their budding of Scotch pine is often carried to such an extent that the tree resembles a bush more than a well formed pine. The stem deviates from the perpendicular and instead of a single pole there may be several, all vying for leadership at the expense of the tree as

a whole. For lumber purposes the tree becomes valueless. The damage in some plantations is so extensive that the whole plantation as a source of lumber is a loss.

Norway spruce is affected by the loss of the leader and subsequent wasteful competition. The effect caused by budding of laterals cannot be serious in reducing foliage area for the tree sends out new buds near the site of the injury. But the formation of new buds must be at the expense of the growth of the trees, for the early growing period is thus lost.

That squirrels bark maple and other trees during winter and spring in many localities is well recognized, and probably the same source of food supply is utilized in the Harvard Forest, though so far as known it has not actually been observed. In undisturbed areas where food is abundant and the animals are held in check by natural enemies there probably is less injury of this sort than nearer farms and cities where the reverse conditions prevail. That such injury to trees has a harmful effect is yet to be demonstrated.

The red squirrels cut vast quantities of the fruits of local trees and utilize many of the seeds for food, either immediately or at a later time when other food is scarce. Cones of white pine, red spruce (Fig. 194), hemlock and arbor vitae are cut and stored in underground pockets, but the seeds are not removed until such a time as the animal is ready to utilize them. That a large percentage of these buried stores are never again touched is a commonly accepted fact. That the trees suffer from this loss of seed seems incredible when one sees the vast number of seedlings that litter the forest floor; but that they ordinarily benefit from having the seeds planted for them is doubtful, since the cones are not usually buried at the proper depth or at a place suitable to encourage germination. These pockets are most frequently located under old logs or stumps, under living trees or under rocks—places where a germinating seed would never thrive. However, areas denuded by fires or lumbering are seeded from these buried stores through the efforts of squirrels from the adjacent forest that inadvertently drop a certain percentage of the seeds as they nip off the scales of the cones while perched on a stump, rock or log. Here the seeds are likely to find a favorable bed for germination.

During early September one pair of captive squirrels consumed the seed of 422 second year pine cones during one week of feeding. The only other food supplied them was apples of which they ate three during the same period. This number of cones represented approximately the total crop of two fifty-year-old trees during the

summer of 1925. In the natural state the squirrels at this time of year feed on large quantities of mushrooms, hazelnuts, and other foods, as well as on white pine seed. It seems then unlikely that a pair of squirrels working in the forest would at this time of year actually consume quite so large a quantity of pine seeds as did the captives, though they might cut an even larger number of cones for future use.

Late in August when squirrels in the spruce swamp were cutting off vast quantities of green cones the writer placed 90 such cones in a cage containing a pair of red squirrels. Though these individuals worked all of the seeds out from their scales they ate few or none of them, as was attested by the débris sifted from the cage.

Red squirrels within the forest were found feeding on butternuts, chestnuts, acorns of red oak, Scotch pine seeds and seeds of wild red cherry. It was reported, too, that they fed on the keys of the red maple in the spring. Elsewhere the author has found them feeding on the fruits of elm, apple, gray birch, and shag-bark hickory. It is presumed that the red squirrels of the Harvard Forest utilize these same food sources. Hornbeam, beech, white ash, white oak, and hawthorn are in all probability among the fruit trees of the squirrel though no definite records were obtained for these species.

The squirrels do not rely solely on trees for food but utilize as well the smaller plants. Until more is known of the importance of these various species composing forest undergrowth one cannot make any pretense of estimating the effect produced by the squirrels upon the forest trees through this source. Hazelnuts are used extensively by the red squirrels for autumn and winter food, and these animals are thus in keen competition with the chipmunks for this crop. Residents of the Petersham area rarely gather hazelnuts, so that the squirrel engenders no enmities in that direction. A pair of captive squirrels consumed 242 hazelnuts per day when fed no other food.

The late low blueberry (*Vaccinium vacillans*) which grows commonly in the forest was utilized to a considerable extent as current food supply. This species because of its low growth habit is not in demand by man, and the crop of berries is always far in excess of the demands made upon it by all other species, so that the squirrels take no more than a legitimate share.

Mushrooms of many species are used as food throughout the summer, and some of these are stored. The forms *Boletus, Russula,* and *Amanita muscaria* were commonly eaten. No economic importance can be attached to this unless it be the indirect one of the animals having an additional source of food which will save the trees from some little further damage.

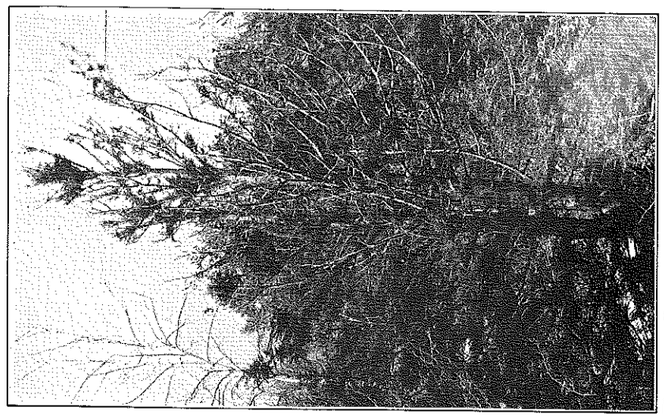

Fig. 209. Two mature hemlocks with all small twigs clipped by feeding porcupine. Photograph by A. C. Cline.

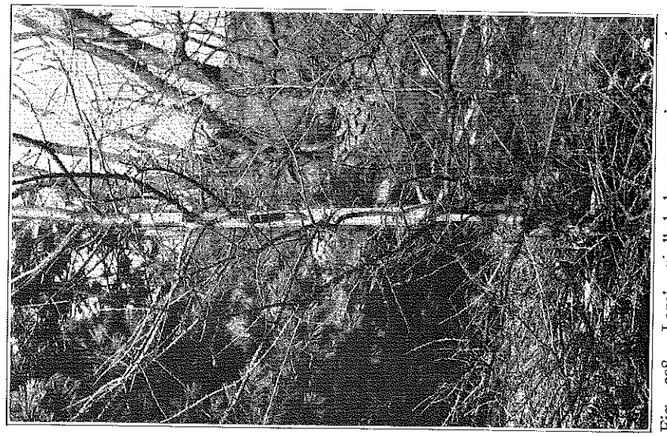

Fig. 208. Larch girdled by porcupine on the Harvard Forest. Photograph by A. C. Cline.

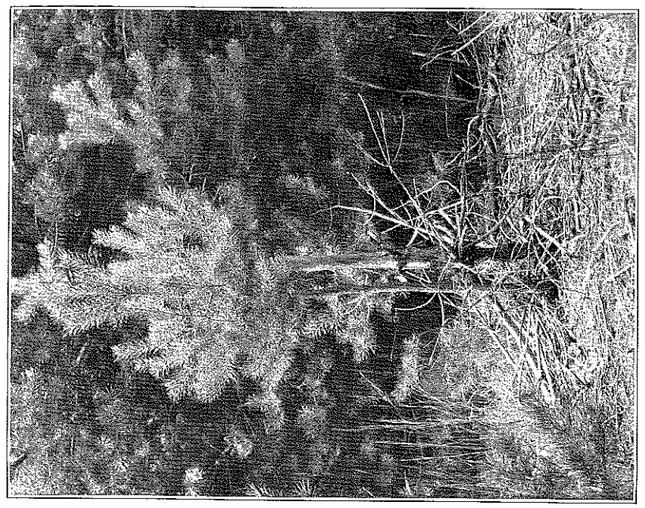

Fig. 211. A Scotch pine girdled by mice, which has sent up a new shoot from the base to replace the dead stem. September 10, 1925.

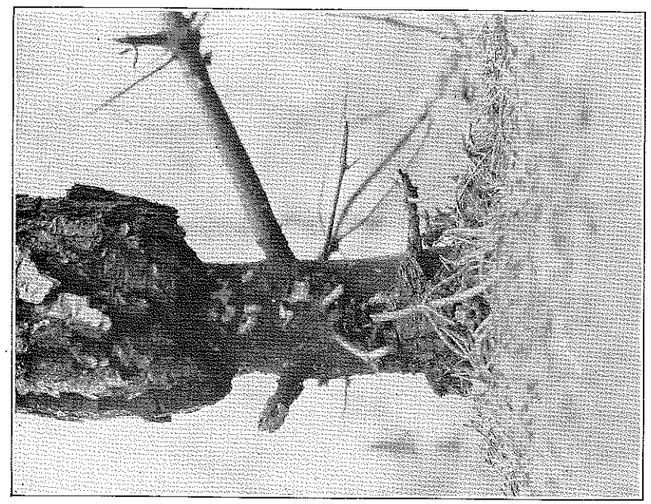

Fig. 210. The base of a Scotch pine completely girdled by mice, North Ashburnham, Massachusetts. July 18, 1925.

Gardens in the Petersham area are rarely molested, so far as could be learned.

The one remaining consideration relates to the squirrels as bird destroyers. This much discussed predatory habit is greatly overestimated by most people. That the squirrel does destroy eggs and nestlings of birds cannot be denied, but it appears to be an unusual thing. Seemingly only a few individuals possess the habit and they do not frequently follow such carnivorous inclinations. But one case of the kind came under the writer's personal observation. Here an immature red squirrel killed the nestlings of a black-throated green warbler, ate parts of the bodies and stored one in a pine as though for future use.

The case of the red squirrel is one calling for careful and unbiased judgment. A consideration of all its habits shows the squirrel to do as much good as harm in natural areas. Locally the species may at times become a pest, and then control measures must be adopted. In the Harvard Forest the only squirrel populations that need control are those in areas adjacent to plantations of larch, Scotch pine and Norway spruce. If during periods of heavy snowfall, the squirrels were to be shot, trapped, or, perhaps with greater economy, supplied with grain or scraps for food, the plantations might be unharmed. If abundant food were supplied during critical periods in the areas adjacent to plantations both trees and squirrels could possibly be kept alive. Trouble arises not in the relation of the squirrel to the native flora, but in introducing exotic species into an environment to which they have not been adapted by ages of natural selection.

Porcupine. The damage caused by this mammal at the present time appears to be limited to the barking of plantation trees of European larch and Scotch pine and to defoliation and barking of native hemlock. The only phase that is now of serious economic importance is the destruction of plantation trees. In two plantations of larch the trees injured exceeded twenty per cent of the number planted, and the number of these injured trees which died as the result of injury approximated three-fourths of the molested number. Scotch pine on the Forest has not yet been touched, but the seriousness of the damage in a nearby area warrants the expectation that the porcupines will soon become a pest to this species in the Harvard Forest, also. Such damage would appear to be controlled best locally during the winter months when porcupines can most easily be seen or tracked. The managers of the Forest, as a matter of

fact, have not found this an easy thing to do, for in 1923 twenty-one porcupines were killed around a small larch plantation without their numbers being accounted for completely. Damage to the trees continued practically undiminished in subsequent years.

It is not known that this species is of any benefit to the forest and for purposes of economy it would seem expedient to control their numbers by shooting and trapping during the winter months. Since the porcupine has but recently come into the region it is inconceivable that its extermination would disturb the balance of nature in this district.

Mice. Mice of one of the microtine species have done extensive damage to one Scotch pine plantation in the Forest. They have destroyed about twenty-five per cent of the trees in the stand.

The rôle that mice play in forestry is not sufficiently known. In times of over-population some species do enormous damage to forest and orchard trees. Even in years of ordinary populations bark-feeding may be locally serious, but in all probability this is usually offset by the good which they do.

The best known benefit derived by the forests from voles has recently been described by Graham ('28). He has shown that by feeding on the pupae of the larch sawfly, *Microtus* may prevent these insects from becoming epidemic.

The subject of the economic status of the voles is considered more at length in the preceding paper.

Deer. As previously stated, the deer damage is not so immediately serious as that caused by rodents. With a yearly open season on deer there has not been, nor is there likely to be, any over-abundance of the species. At their present population they cannot be accused of damage great enough to offset the pleasure they afford to hunters or other recreation seekers in the Forest. The only practical control measure that might be undertaken against the deer would seem to be the fencing of young growth, but this to be effective might entail an expense that would be prohibitive.

THE INFLUENCE OF MAMMALS IN THE CULTIVATION OF VARIOUS SPECIES OF TREES

Larch. European larch has been used as a plantation tree in the Forest with unfortunate results. Squirrels, porcupines and the larch sawfly combine to make existence almost impossible for the species.

Six plantations of larch were surveyed in which the degree of damage by each species varied. A complete record was kept of all porcupine, squirrel and sawfly damage for one representative plantation. Of the trees in this stand, nine per cent were injured by porcupines (six per cent killed), sixty-three per cent were squirrel-cut and seventy per cent infested by sawfly larvae. A total of eighty per cent of the trees was damaged by one or more of these animals. The dead and dying constituted eleven per cent. The trees of this plantation were about twelve years old, and as the three enemies have but recently attacked them and shall probably continue to do so, the larches stand small chance of heavy survival.

Another plantation showed twenty per cent porcupine injury (sixteen per cent killed) and forty-one per cent red squirrel injury.

Still another had twenty-two per cent of the trees injured by porcupines (twelve per cent killed) and forty-three per cent damaged by red squirrels. Two other plantations with negligible porcupine damage showed every tree partly trimmed by red squirrels. Sawfly defoliation was found on sixty per cent of the trees in these stands. Damage to one of the plantations (P. H. VII, w) was so thorough that it is doubtful that the trees will live to a marketable age.

That they are to some extent protected by mice from further sawfly injury is probable, as Graham ('28) has shown that in the mid-western states *Microtus* feeds extensively on the pupae of this pest.

Scotch Pine. Scotch pine has been sporadically attacked in the region by mice and porcupines, each of which has made a serious inroad at the place of infestation. These two mammals while taking a toll of life among the trees have not in themselves ruined any one plantation beyond utilization. The red squirrel, though not actually killing trees has, however, in several stands so seriously deformed them through repeated feeding on the winter buds that commercially these trees are of but little value. Mouse damage is rare, though severe when it does occur. Porcupines probably feed continuously in a plantation but not in all plantations, while squirrels cause damage every winter in every plantation.

The plantation at North Ashburnham showed fifty-nine per cent of the trees injured by mice, half of which died. Porcupines had damaged thirty-two per cent of the trees, ten per cent of which subsequently died. Red squirrels had budded eighty-eight per cent of the whole. In all, mammals had killed thirty-two per cent of the trees and seriously injured about ninety per cent of all. Approximately eighty per cent of the trees planted could never be used for lumber, even though they might not be damaged further, which is hardly to be thought likely.

A plantation on the Harvard Forest (P. H. VIII, x) had fifty-one per cent of its trees girdled by mice, twenty-one per cent of all the trees being killed from this cause. In addition the stand had received damage to fifty per cent of its trees by red squirrels, though this injury was serious in relatively few cases. Two other plantations showed red squirrel damage to every tree, but had not been injured by any other mammal.

The serious effect of red squirrel injury is illustrated by a census of one hundred Scotch pines in which the number of times each had been robbed of its terminal bud was noted. Twelve had never had the leader injured, twenty-eight were injured but once, forty-two, twice; twelve, three times; five, four times; and one, five times. A total of eighty-eight were thus deformed.

The extent of cutting on a single tree was determined by selecting a representative individual and counting the number of lateral branches whose buds had been removed in each of the two preceding winters. During the winter 1924–1925 thirty-four per cent of the buds were removed, while in 1923–1924 thirty-two per cent were cut. As previously pointed out, this really does no injury to the tree as it only increases the leaf area, in contrast to the cutting of leaders which leads to serious consequences. A count of damaged leaders in this same plantation showed that at some time every tree had been attacked. The winter of 1923–1924 showed the greatest amount of damage, that of 1922–1923 the least, and that of 1924–1925 an amount intermediate between the others. It is said that the winter of 1923–1924 was the most severe of these three.

Norway Spruce. Red squirrels are the only mammals harming Norway spruce in the Harvard Forest. Their damage is usually not so serious as with other species of trees since defoliation is not great; and even though a leader is cut, ordinarily but a single lateral, close to the site of the original leader, grows upward. In time the tree straightens out and is not materially the worse for the loss of its

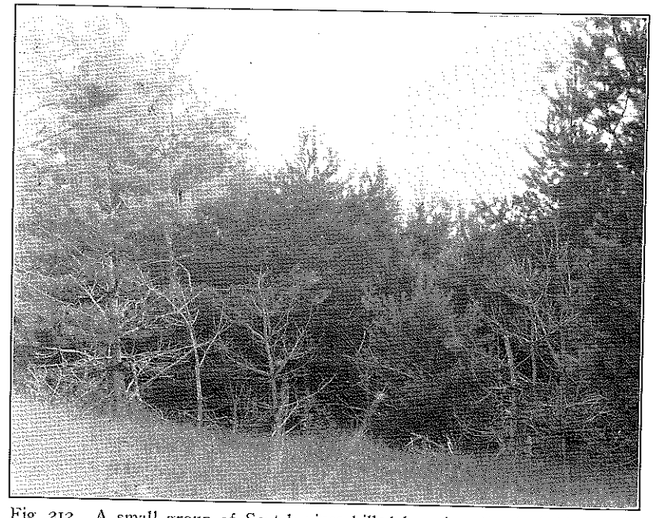

Fig. 212. A small group of Scotch pines killed by mice, North Ashburnham, Massachusetts. July 18, 1925.

Fig. 213. Pure growth white pine, Harvard Forest. August 10, 1925.

leader. Red squirrel injury coupled with that of the white pine weevil, which also kills the leader, must result in a considerable growth loss to the plantation as a whole, even though the individual tree does not show a very serious result.

Plantations which have escaped injury altogether were either too young to appear as trees above the snow or else were near a habitat which appeared to furnish enough food to keep the squirrels from feeding on spruce. Damage within a single plantation varied from one with no cuttings at all, to a stand in which every tree had been clipped and in which the terminals on ten per cent of the trees had at some time been cut.

Experimental Mixture. There is a one-acre plantation laid out in alternate rows of white pine, Scotch pine, western yellow pine, Norway spruce and Douglas fir. These trees were about eighteen years old when examined. They are closely planted and vary in height with the growth habits of the species. No trees except Norway spruce and Scotch pine had suffered injury by mammals. The damage to the spruce was not serious in any row, many trees not being affected at all. Scotch pines were already residence sites of squirrels and here the animals fed from both cones and buds. One single isolated row of Scotch pine showed no damage, and another, very light damage; but a strip three rows deep had some fifty per cent of the trees injured, and another, four rows wide, eighty per cent. Five other rows which were alternated with rows of white pine were too dense to allow a careful examination to be made, but about seventy-five per cent had been subjected to budding. The trees were in no case so seriously affected as were trees seen in pure stands.

General Considerations. The foregoing facts reveal several obvious errors in previous planting practice.

Small-sized plantations, particularly when placed near to or in a mature, though not old, forest, have been subject to thorough and constant injury by mammals feeding upon them. It would appear from this to be inadvisable to establish very small plantations within or near a forest from which mammals have easy access to all its parts, unless it be planted with a species known to be immune to such animal injury.

Exotic trees (Scotch pine, European larch and Norway spruce) have suffered more from the inroads of mammals than have indigenous forms. It would seem desirable, therefore, if market and

insect conditions are favorable, to use native species of trees where they are to be raised with a profit on the investment.

Pure stands have perhaps proved the gravest error for they have in many cases been subject to the attacks of insects and mammals to such an extent that the plantation is practically worthless, and the land on which they grow has in effect been idle. If alternate rows of different species are planted each species seems to enjoy a little more immunity than would otherwise have been its lot, and the plantation, even though the entire quota of one species be destroyed, may still thrive, and the development of a profitable stand may not be delayed.

That surrounding habitats play a most important rôle with mammals as well as with insects is illustrated by many facts. Norway spruce planted near one old and extensive forest of white pine and hardwood, the crown of which bore an abundant harvest and the underbrush of which contained a good growth of hazelnuts, was not subject to squirrel injury. This escape was seemingly because of a better balanced fauna and flora accompanying advanced age. Another spruce plantation, over four acres in area, was bordered on two sides by open fields, on the third by pasture with scattered pine occurring in it, and on the fourth by a mature growth of white pine and hardwood. The positions of injured and uninjured trees in the plantation were carefully mapped, the resulting plot showing clearly, by intensity of damage, an invasion of the plantation by red squirrels from the forest and from a stone wall leading out from the forest, along one border of the plantation. The corner farthest from the forest and fence showed by far the least damage, being in fact, practically untouched.

BIBLIOGRAPHY

BAILEY, V.
1924. Breeding, Feeding and Other Life Habits of Meadow Mice (*Microtus*). Jour. Agric. Research, Vol. 27, No. 8, pp. 523–536.

BALLOU, F. H.
1909. Protection of Fruit Trees from Rodents. Bull. Ohio. Agric. Exp. Sta., No. 208, pp. 53–70.

BOWLES, J. H.
1920. The California Gray Squirrel An Enemy to the Douglas Fir. Amer. Forestry, Vol. 26, p. 26.

FISHER, R. T.
1921. The Management of the Harvard Forest, 1909–1919. Harvard Forest Bull. 1, pp. 1–27.
1924. Catalog of Representative Operations on the Harvard Forest. Pp. 1–11. Athol, Mass.

GRAHAM, S. A.
1928. The Influence of Small Mammals and Other Factors Upon the Larch Sawfly Survival. Jour. Economic Entomology, Vol. 21, No. 2, pp. 301–310.

GRINNELL, J.
1924. Wild Animal Life as a Product and as a Necessity of National Forests. Jour. Forestry, Vol. 22, No. 8, pp. 837–845.

HARTIG, R.
1895. Doppelringe als Folge von Spätfrost. Forstliche Naturwissenschaftliche Zeitung, Vol. 4, pp. 1–8. (Original not seen—R. T. H.)

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 Wild Life Annals, Vol. 2, No. 1, pp. 1–146.

HOFMANN, J. V.
1920. The Establishment of a Douglas Fir Forest. Ecology, Vol. 1, pp. 49–53.

HOSLEY, N. W.
1925. A Mystery of the Tree Tops. Amer. Forests and Forest Life, Vol. 31, pp. 455–457.
1928. Red Squirrel Damage of Coniferous Plantations and its Relation to Changing Food Habits. Ecology, Vol. 9, pp. 43–48.

JACK, J. G.
1911. Trees and Other Woody Plants Found in the Harvard Forest, Petersham, Massachusetts. Bull. Harvard Forestry Club, Vol. 1, pp. 1–18.

JOHNSON, C. E.
1918. Squirrels and Chipmunks in Autumn. Ottawa Nat., Vol. 32, No. 3, p. 54.

LANTZ, D. E.
1906. Meadow Mice in Relation to Agriculture and Horticulture. U. S. Dept. Agric. Yrbk. for 1905, pp. 363–376.
1907. An Economic Study of the Field Mice (Genus *Microtus*). U. S. Dept. Agric., Biol. Survey Bull. No. 31, pp. 1–64.
1916. Cottontail Rabbits in Relation to Trees and Farm Crops. U. S. Dept. Agric., Farmers' Bull. No. 702, pp. 1–12.
1918. Field Mice as Farm and Orchard Pests. U. S. Dept. Agric., Farmers' Bull. No. 670, pp. 1–12.

NICHOLS, J. T.
1927. Notes on the Food Habits of the Gray Squirrel. Jour. Mammalogy, Vol. 8, pp. 55–57.

PEIRSON, H. B.
1924. Estimating Forest Insect Damage. Maine Forest Service Bull., No. 3, pp. 1–22.

SHUFELDT, R. W.
1920. Four-footed Foresters—the Squirrels. Amer. Forestry, Vol. 26, pp. 37–44.

SILVER, J.
1924. Mouse Control in Field and Orchard. U. S. Dept. Agric., Farmers' Bull. No. 1397, pp. 1–14.

STONER, D.
1918. The Rodents of Iowa. Iowa Geol. Survey Bull., No. 5, pp. 1–172.

THOREAU, H. D.
1906. The Succession of Forest Trees (An Address Read to the Middlesex Agricultural Society in Concord, September 1860). The Writings of Thoreau, Manuscript Ed., Vol. 5, pp. 184–204. Boston.

THE ROOSEVELT WILD LIFE MEMORIAL

As a State Memorial

The State of New York is the trustee of this wild life Memorial to Theodore Roosevelt. The New York State College of Forestry at Syracuse is a State institution supported solely by State funds, and the Roosevelt Wild Life Forest Experiment Station is a part of this institution. The Trustees are State officials. A legislative mandate instructed them as follows:

"To establish and conduct an experimental station to be known as 'Roosevelt Wild Life Forest Experiment Station,' in which there shall be maintained records of the results of the experiments and investigations made and research work accomplished; also a library of works, publications, papers and data having to do with wild life, together with means for practical illustration and demonstration, which library shall, at all reasonable hours, be open to the public." [Laws of New York, chapter 536. Became a law May 10, 1919.]

As a General Memorial

While this Memorial Station was founded by New York State, its functions are not limited solely to the State. The Trustees are further authorized to cooperate with other agencies, so that the work is by no means limited to the boundaries of the State or by State funds. Provision for this has been made by the law as follows:

"To enter into any contract necessary or appropriate for carrying out any of the purposes or objects of the College, including such as shall involve cooperation with any person, corporation or association or any department of the government of the State of New York or of the United States in laboratory, experimental, investigative or research work, and the acceptance from such persons, corporation, association, or department of the State or Federal government of gifts or contributions of money, expert service, labor, materials, apparatus, appliances or other property in connection therewith." [Laws of New York, chapter 42. Became a law March 7, 1918.]

By these laws the Empire State has made provision to conduct forest wild life research upon a comprehensive basis, and on a plan as broad as that approved by Theodore Roosevelt himself.

(Reprinted: original date of publication, 1877.)