RED SQUIRREL DAMAGE TO CONIFEROUS PLANTATIONS AND ITS RELATION TO CHANGING FOOD HABITS

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For several years a winter injury of unknown cause had been noticed in central Massachusetts coniferous planatations by members of the Harvard Forest staff. Twigs were cut off as cleanly as though by a knife, and in sufficient quantities to cause real damage to the trees. During the winter of 1924–25. a study of the injury was made.

To find the cause of the damage, several plantations were watched during early winter until, with the first heavy fall of snow, the clipping began. Then a plantation of Scotch pine (*Pinus silvestris*) where the activity appeared to be greatest, was watched from a blind until a red squirrel, *Sciurus hudsonicus loquax* Bangs [1] was seen doing the cutting. A study of the squirrel's habits here made it possible to identify him as the cause of all other fresh work found. He was also later seen eating European larch (*Larix europaea*) and white pine (*Pinus strobus*) buds.

The next objective was to find out from the forester's standpoint how serious the injuries were. The damage takes place only when it is difficult or impossible for the squirrel to find food on the ground. A period of warm weather following such a time and resulting in the thinning of the snow to a few inches in depth greatly reduces the amount of damage per day. An exception to this general statement is that European larch and white pine buds, at least, are eaten when they are just beginning to swell in the spring.

Scotch pine, Norway spruce (*Picea Abies*) and European larch are heavily injured. Only one red pine (*Pinus resinosa*) was found damaged out of hundreds examined. White pine is ordinarily immune, but in a winter of deep snow a heavy leader injury takes place. Often a group of young trees will be over ninety per cent injured, and in one case trees up to 25 feet tall lost their terminals. Red spruce (*Picea rubens*) is apparently ignored entirely. It was thought that white spruce (*Picea canadensis*), a species introduced from further north, but which grows vigorously in northern Massachusetts, would be strongly attacked. Examination of several hundred trees in a 19 year old plantation showed only one injury per hundred, while a nearby stand of Norway spruce was heavily damaged.

Besides the region where the study was made, the author has found the injury in northeastern Massachusetts, northern Connecticut and central New York. So it is by no means local, and probably occurs throughout the range

[1] Local variety determined by Robert T. Hatt.

of the two sub-species, *Sciurus hudsonicus loquax* Bangs and *Sciurus hudsonicus gymnicus* Bangs.

Injury to Scotch Pine (*Pinus silvestris*)

Scotch pine suffers most of any species studied. The large bud clusters seem to have a great attraction. The twigs are large and hard to cut. The buds are all in the end cluster, and so are usually cut off where the wood begins. The contents are cleaned out, and the split sheaths dropped down to litter the snow. A cluster of terminal buds is usually eaten clean (Fig. 1) leaving none to carry on normal height growth. Usually, at the same time, the topmost whorl of lateral branches and an occasional one lower down is clipped. The species has the ability of adventitious growth which causes a very characteristic form. Many of the terminal needle fascicles apparently form branchlets giving an enlarged, "broomed" appearance to the branch. A single injury can be outgrown, but the numerous branchlets get a fair start during one growing season and are often subjected to new injury the following winter. When this has been repeated for three or four successive years the production of good quality lumber by the tree is postponed if not prevented. The data on damage of 1924–25 could be easily recorded for different classes of injury, but earlier years were much more difficult to determine, so only "injured" and "uninjured" groups were made for the earlier season.

The winter of 1923–24 was one with a very high percentage of injury. Weather records taken at the Forest Headquarters show that from November 1 to March 31 the precipitation in 1923–24 was 4.3 inches more than in 1924–25 and 3.0 inches more than the average for the ten years ending with March 1925. As a contrast, the precipitation in the 1924–25 period was 1.2 inches below the ten year average. The data for the two winters from five plantations in Petersham, bring out the comparisons of resultant damage very clearly.

Table I. *Injury of 1923–24 in Pinus Silvestris; (heavy snow)*

Plantation Number	Area in Acres	Age in Years	No. Trees Examined	Percentage of trees injured	Percentage of trees uninjured
1	1.3	16	50	92	8
2	.6	15	50	90	10
3	.4	16	50	100*	—
4	.7	15	50	98**	2
5	1.0	14	100	86	14
Totals and averages...	4.0		300	93.2	6.8

* 1922–23 injury 100 per cent, not included in that for 1923–24.

** 1922–23 injury 82 per cent, not included in that for 1923–24.

TABLE II. *Injury of 1924–25 Pinus silvestris; (below normal snowfall)*

Plantation Number	Percentages				
	Part of Tree Injured			Total Injured	Total Uninjured
	Terminal Only	Terminal and Laterals	Laterals Only		
1	4	14	6	24	76
2	—	82	8	90	10
3	2	84	8	94	6
4	2	66	2	70	30
5	—	—	—	—	100
Averages.....	1.6	49.2	4.8	55.6	44.4

INJURY TO NORWAY SPRUCE (*Picea Abies*)

The bud arrangement on Norway spruce twigs leads to a different method of attack from that in Scotch pine. The terminal bud is well armored by many sharp, forward-pointing, stiff needles and cannot well be eaten from the end, so a cut is made at the base; the green tissue is taken out and the bud sheath is left looking so nearly normal that it would not often be noticed as damaged by one not familiar with the injury. These end buds are sometimes all that are touched on the branch, but the lateral ones near the tip usually suffer also. They are like small, fat brussels sprouts and make very easy feeding for the squirrel. A twig or leader tip a few inches long carries several of these buds. Apparently to save effort, a twig is cut off from one-half to five inches back from the end and taken to a point on a larger branch where it can be wedged among the thick needles and the contents of the buds hollowed out (Fig. 2). Often dozens of these rifled tips can be found in one tree. The cutting does not seem to be confined to any one part of the tree. In larger specimens, where the leaders have reached a diameter of three-quarters of an inch or more, the buds usually are untouched. Where the leaders are small they are riddled and most of the lateral branches having sizeable buds are given the same treatment on all trees alike (Fig. 3). Only slow-growing or unhealthy trees with small buds escape.

Recovery from the injury is more rapid and more successful than in Scotch pine. The strong, centralized, upward growth from lateral buds left untouched soon replaces the leader. Usually only one good shoot results, and this straightens out at the point of injury so well that in a year's time the only evidence of the damage is the dead stub of the former leader protruding at a point where there is a slight crook. As wood is lain on for a few years over this section, the crook largely disappears. Lateral branches never make any further growth at the injured tips.

The comparative amounts of injury in the two winters studied is shown in the following tables covering four areas in Petersham and one in Clinton, Massachusetts. The same trees were used for the different years.

TABLE III. *Injury of 1923–24, Picea Abies*

Plantation Number	Area in Acres	Age in Years	No. trees examined	Percentage of trees injured	Percentage of trees uninjured
1	2.4	14	50	74*	26
2	2.9	11	50	64†	36
3	.1	16	50	96‡	4
4	1.0	16	50	32	68
5	2.0	19	100	75	25
Totals and averages . .	8.4		300	68.2	31.8

* 1922–23 injury 64 per cent, not included in that for 1923–24.
† 1922–23 injury 44 per cent, not included in that for 1923–24.
‡ 1922–23 injury 90 per cent, not included in that for 1923–24.

TABLE IV. *Injury of 1924–25 Picea Abies*

Plantation Number	Percentages				
	Part of Tree Injured			Total Injured	Total Uninjured
	Terminal Only	Terminal and Laterals	Laterals Only		
1	—	—	—	—	100
2	—	—	—	—	100
3	—	24	34	58	42
4	—	—	—	—	100
5	—	8	49	57	43
Averages.	0	6.4	16.6	23	77

INJURY TO EUROPEAN LARCH (*Larix europaea*)

The injury in European larch of the sizes available for study (12–29 feet tall) is one of lateral bud eating only. There are two types of work. One takes off the small twigs which grow in great numbers from the main stem. The other takes the tips from the large limbs. A rather long section is cut off in either case. Fifty cuttings picked at random gave an average length of 10.9 inches. They are, of course, very light and slender. The buds are small, and those on new growth are eaten from the tip end. On year-old branches they are usually cut in from the side to remove the contents. The twigs are dropped to the snow at the base of the tree (Fig. 4) and in summer the accumulation from two or three years' work often forms a thick mat.

When the buds are just beginning to show growth in the spring, a second session of damage occurs, but the buds only are removed, leaving the twigs intact.

Only very severe cases of damage seem appreciably to retard the growth of the trees. When a stem is clipped up to almost a bare pole it, of course, can make little growth. This is, however, exceptional, and recovery usually seems well under way the first season.

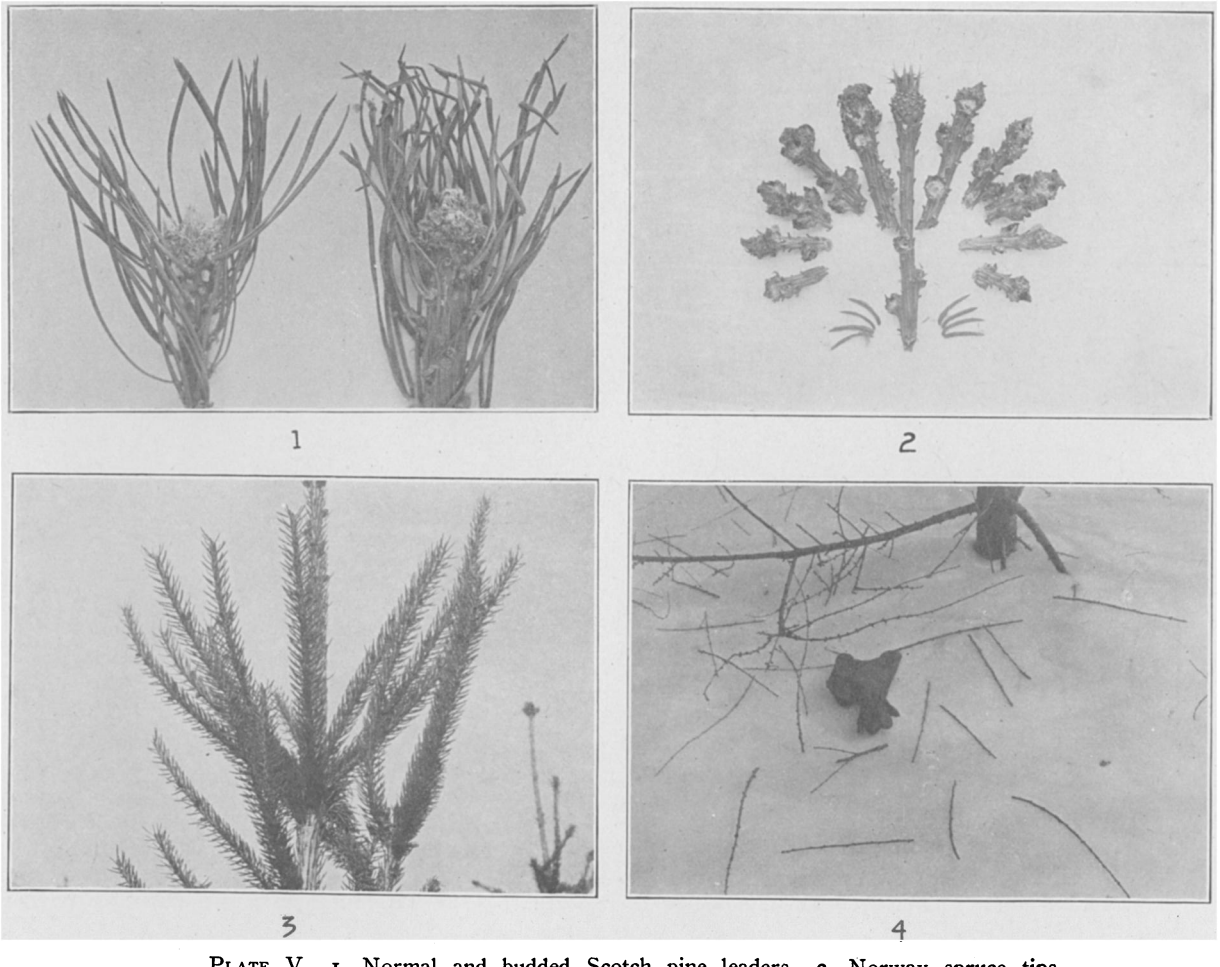

PLATE V. 1. Normal and budded Scotch pine leaders. 2. Norway spruce tips with rifled buds. 3. Norway spruce branch clipping. 4. European larch twigs dropped on the snow after buds were eaten.

That larch is not as eagerly eaten as Scotch pine is evidenced by the fact that in adjoining, nearly equal-aged plantations of the two species, larch show no injury during 1924–25 while 90 per cent of the pines were attacked.

Nine plantations covering 4.0 acres were studied, and only two of these were damaged in a rather spotty way during the time of observation, although each had been thoroughly attacked in previous winters. No representative figures on the amount of damage could be gotten from these. Data on past injury is very hard to obtain because the rapid growth from cut twigs makes determination of the year of injury little more than guesswork. The twigs dropped to the ground are of no greater help, because they are often mixed with those left by rabbits gnawing at lower limbs and by porcupines working higher up. The buds go to pieces quickly, and after they are gone it is impossible to tell whether the work was done by squirrels or not.

Damage of 1925–26

No data on the amount of the injury during 1925–26 were taken, but several plantations of the three injured species were under observation during the period of deep snow. While the precipitation from November first to April first was only .3 inch greater than in the same part of 1924–25, and .87 inch less than the ten year average mentioned above, the snow lay from two to six feet deep in the plantations for an unusually long, unbroken period.

The damage was heavier by far than in either of the two previous winters. It was carried uniformly over all the trees, and practically all sizeable, lateral branches as well as the terminals of the spruce and pine were budded.

Changing Food Habits a Possible Cause of the Injury

Why the squirrel did not damage plantations until recent years is a question naturally arising in the course of the study. Biologists tell us that something of real importance must happen to change the feeding habits of an animal over a considerable area. The squirrel is not limited in travel to a small circle surrounding his nest, as is evidenced by the fact that in one of the spruce plantations studied the injury was carried uniformly out to the edge which was six hundred feet from the nearest forest cover. Paulmier [2] claims that squirrels have been known to cross a lake during the fall in search of a good crop of chestnuts. This response to food supply seems to explain the limiting of the injury to recent years. The original, old-growth, mixed forest contained large trees that bore a variety of squirrel foods. The pines were old enough to bear cones in abundance. The oak, beech and chestnut furnished such a quantity of mast that pigs could be fattened on it. This condition has been radically changed. Logging has left in place of the old pines only young ones bearing relatively few cones, many of which never mature due to insect infestations. Areas denuded of their mast-bearing hard-

[2] Paulmier, Frederic C. "The squirrels and other rodents of the Adirondacks." Report of the Conservation Commission of New York. 1902–03.

woods have seeded in to species whose winged seeds are easily wind blown. Only an occasional oak or beech too young to bear fruit is found among them. The chestnut, a great food producer of former years, is so completely wiped out by the blight that a nut-bearing tree is a rarity in this region. The present day cut-over land has a growth in which squirrel food during the spring and summer is abundant, but in which supplies for winter storing are very hard to find. The result seems obvious. The coniferous plantations whose largs buds are eatable offers a good emergency ration when the snow's depth prevents finding food on the ground. This behavior is not from preference but from necessity. That natural winter food obtainable through the snow will result in comparative freedom from injury in nearby plantations seems to be indicated by one area studied.

About two acres of thirteen year old Norway spruce were examined very carefully. Not a single injury was found until the winter of 1925–26 when a large percentage of the leaders were nipped off. The stand was one such as had invariably been found to be damaged year after year in other locations. There were many squirrels about, so the reason for the comparative immunity appeared to be that the animal's habits here differed from those of the ones around the other plantations. All the repeatedly damaged areas were surrounded for a considerable distance by young stands of white pine and hardwood. Near this area which came so near escaping were acres of old-growth pine, hemlock and hardwood up to a hundred years or more in age. Quantities of pine cones, acorns and beechnuts were available for fall storing, this being one of the few local sections where gray squirrels are still found. Apparently it took a winter when the snow was several feet deep for weeks at a time to make the normal food supply fail. This seems to show that the injury in plantations near similar old-growth is only occasional if not entirely lacking.

Summary

During periods of deep snow when the red squirrel's usual food supply is cut off, it eats the buds of certain coniferous trees, the normal growth of which is thereby retarded. Scotch pine terminal and lateral buds, Norway spruce terminal buds and lateral branch tips, European larch lateral branch-ends, and white pine terminal shoots are clipped off. Scotch pine apparently suffers most, with Norway spruce and white pine close behind. European larch recovers well from the injury.

The intensity of the injury varies directly with the depth of the snow and the length of time it remains between thaws.

The damage has been found by the author in three states, and so is not local.

The fact that the damage has been apparent only in recent years seems to be explained by the lack of pine seed and hardwood mast for winter storing which are less abundant in the present young, cut-over forests of light-seeded species, from which, furthermore, the chestnut has completely disappeared as a source of food.