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REPRODUCTION OF CONIFERS
IN NEW ENGLAND**

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HYLOBIUS PALES AS A FACTOR IN THE REPRODUCTION
OF CONIFERS IN NEW ENGLAND

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It is generally known that there are few areas in New England where white-pine reproduction has been secured promptly after the removal of an old stand of the same species. The reason commonly assigned is that hardwoods, already present under the old stand, grow vigorously after their release and crowd out the pine. This explanation does not always satisfy, however. In one case, the writer advised the removal of a broken stand of limby, pasture-grown pine over a veritable carpet of pine reproduction two to six inches high, with very few hardwoods present. Three years after cutting there were alive not more than ten per acre of these thousands of young pines, and the area was grass-covered. The exposure of the ground is not a sufficient explanation of this almost complete loss. Similarly, plantations of coniferous stock established on recently cut-over pine lands have usually failed. Various theories, such as extreme soil acidity due to rapid decomposition of the leaf litter and humus, have been advanced to explain these failures, but there has been no definite information available on the point heretofore.

In an effort to ascertain the causes of these troubles, a plantation of fairly good 2-1 white-pine stock was established in May, 1914, on the Harvard Forest, Petersham, Mass., on an area from which a heavy stand of pine had been cut clean during the previous winter. The local topography makes the prevailing wind distinctly southwest, and the area planted was near the windward side of the open area. A total of 561 pines were set out carefully, covering about half an acre, with about another 100 Norway spruces set in the partial shade of the adjoining stand. This plantation was inspected about once in two months during the growing seasons of 1914 and 1915, and a record kept of the condition of each tree.

Considering only the white pines at present, the first inspection, on June 26, 1914, showed that there had been a very small planting loss, and that 88 per cent could be classed as thrifty. The second inspection, on August 3, 1914, showed a loss of 11 per cent of the trees, with another 6 per cent weak, thus leaving 83 per cent thrifty. This was somewhat disap-

pointing, but not unsatisfactory. A third inspection was made on September 3, 1914, and it was at once apparent that there had been a heavy loss, and also that many more trees were dying. An examination of a tree then dead, but recorded as thrifty a month before, showed that the bark on the stem had been almost completely removed, leaving the wood bare. On the stems of a number of thrifty living trees snout beetles were found busily devouring the bark, usually on the part of the stem from which the needles had fallen, but sometimes even on the growth of the current year. The loss from this girdling alone had been 16 per cent, disregarding trees reported as dead in August. Another 12 per cent were so badly damaged that death was almost certain, and another 3 per cent had been attacked, but were not yet injured too severely to recover if no more damage occurred. A very careful inspection of the trees recorded as dead in August showed that over a third of them, or 4 per cent of the total number planted, had unquestionably been killed by the same cause, and in this work, as during all subsequent inspections, the beetles were given the benefit of any reasonable doubt. In short, this inspection of September 3, 1914, showed that only 55 per cent of the total number planted were thrifty and uninjured, 3 per cent were weak or sickly as a result of poor planting, drought, or poor stock, 7 per cent had died, presumably without injury from insects, 3 per cent had been partly girdled, 12 per cent had been practically girdled, but still had green needles, and 20 per cent had been killed by these snout beetles.

Prof. C. T. Brues, of the Department of Entomology, Bussey Institution, very kindly consented to identify the specimens of these beetles collected on September 3, 1914, and at later dates. He states that they are *Hylobius pales* Herbst, a beetle known to breed in the bark of pine stumps or of recently killed trees. So far as can be determined, there is no record of the work of this species on the smooth bark of thrifty trees, although in the Year Book of the Department of Agriculture for 1905 there is a statement that "the large stems (of seedlings) are gnawed by wasps, sawfly larvæ, and adults of snout beetles." The wholesale killing of the trees in this plantation and of near-by natural reproduction has surprised the entomologists before whom the facts have been presented.

At each of the subsequent inspections of this plantation *Hylobius* beetles were collected in the act of feeding. The loss plainly attributable to them increased steadily until in September, 1915, it amounted to 61.7 per cent, with an additional 9.5 per cent so severely injured that death seemed certain. Over 70 per cent loss has occurred from this one cause, and only 10.6 per cent loss from all other causes. Less than 20

per cent of the pines planted were alive, and likely to grow if no further insect damage occurred after September 3, 1915, and nearly half of these had been attacked. At least 50 beetles were taken from the area as specimens at the time of the various inspections, and since it seems probable that each would have killed at least one more tree, the actual loss was probably less than if the plantation had not been under close observation. Some trees from which *Hylobius* beetles were taken were not attacked again, and were among the 17.5 per cent called thrifty on September 3, 1915. Observations on this plantation and elsewhere tend to show that the beetles move with the wind rather than against it, so it is unlikely that the loss in this case was increased by the presence of stump land to leeward, not planted until the spring of 1915. The record of the inspections is shown in the accompanying table and diagram. Needless to say, the plantation is considered a failure.

Work of Hylobius Pales in White Pine Plantation G, Harvard Forest, Petersham, Mass.

Condition of trees.	Dates of inspections.						
	6-26-14	8-3-14 ¹	9-3-14	11-4-14	5-19-15	6-18-15	9-3-15 ²
Not injured:	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Thrifty	88	83	55	45.9	35	21.0	9.1
Weak	10	6	3	1.6	5	3.6	.7
Dead	2	7	7	7.1	8	8.2	10.6
Injured:							
Thrifty .....	..	..	3	3.8	5	5.2	8.4
Dying .....	..	..	12	6.8	5	16.0	9.5
Killed .....	..	4	20	34.8	42	46.0 ²	61.7

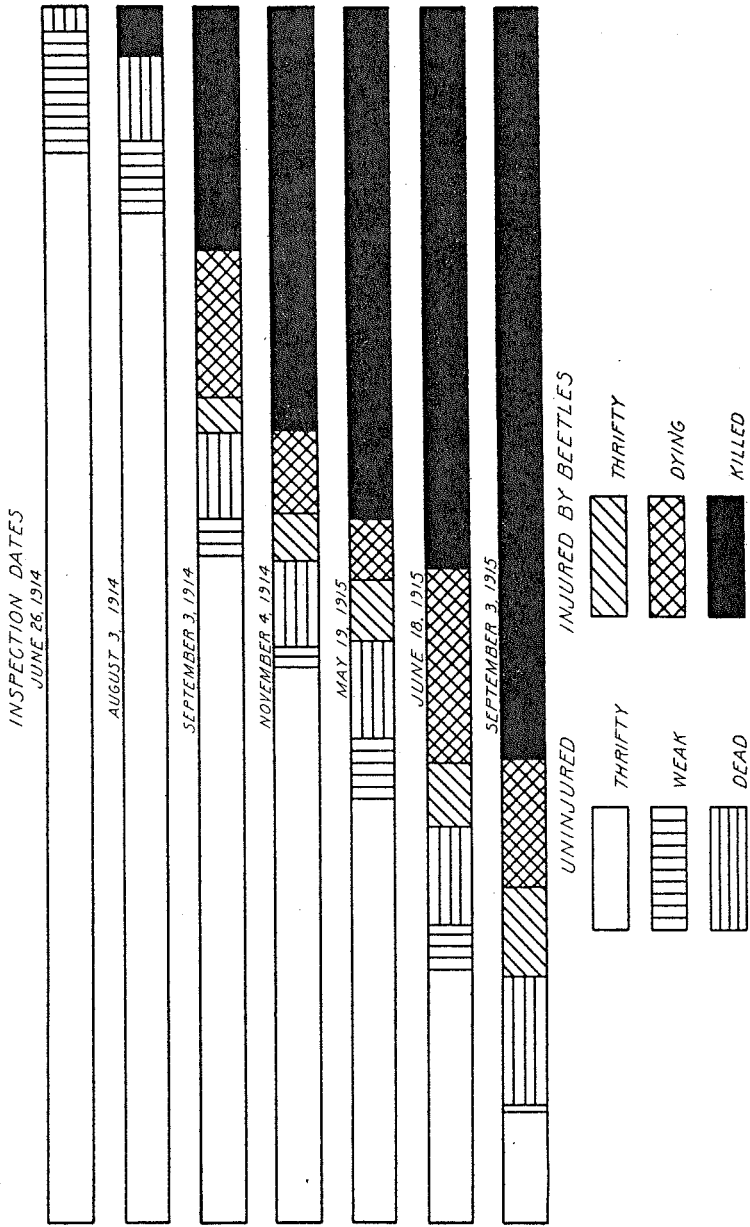
¹ Inspection covered rows 5-13 only.

² Killed by beetles in rows 5-12, 36.1 per cent only.

³ Inspection covered rows 5-12 only.

It required very little investigation to prove that the results in the test plantation were not due to a purely local epidemic. After what was once known, it was easy to find beetles at work within or on the borders of any recently cut-over pine land in Petersham, Mass., or its vicinity. A plantation over 20 miles away, established in May, 1913, on land cut over in the winter of 1912-13 and burned over in April, 1913, showed very heavy loss, from 40 per cent to 80 per cent, and beetles still at work in September, 1914. Natural reproduction, within or on the edges of recently cut-over pine wood lots in Petersham and its vicinity, was seriously damaged both in 1914 and 1915. Repeated inspections of

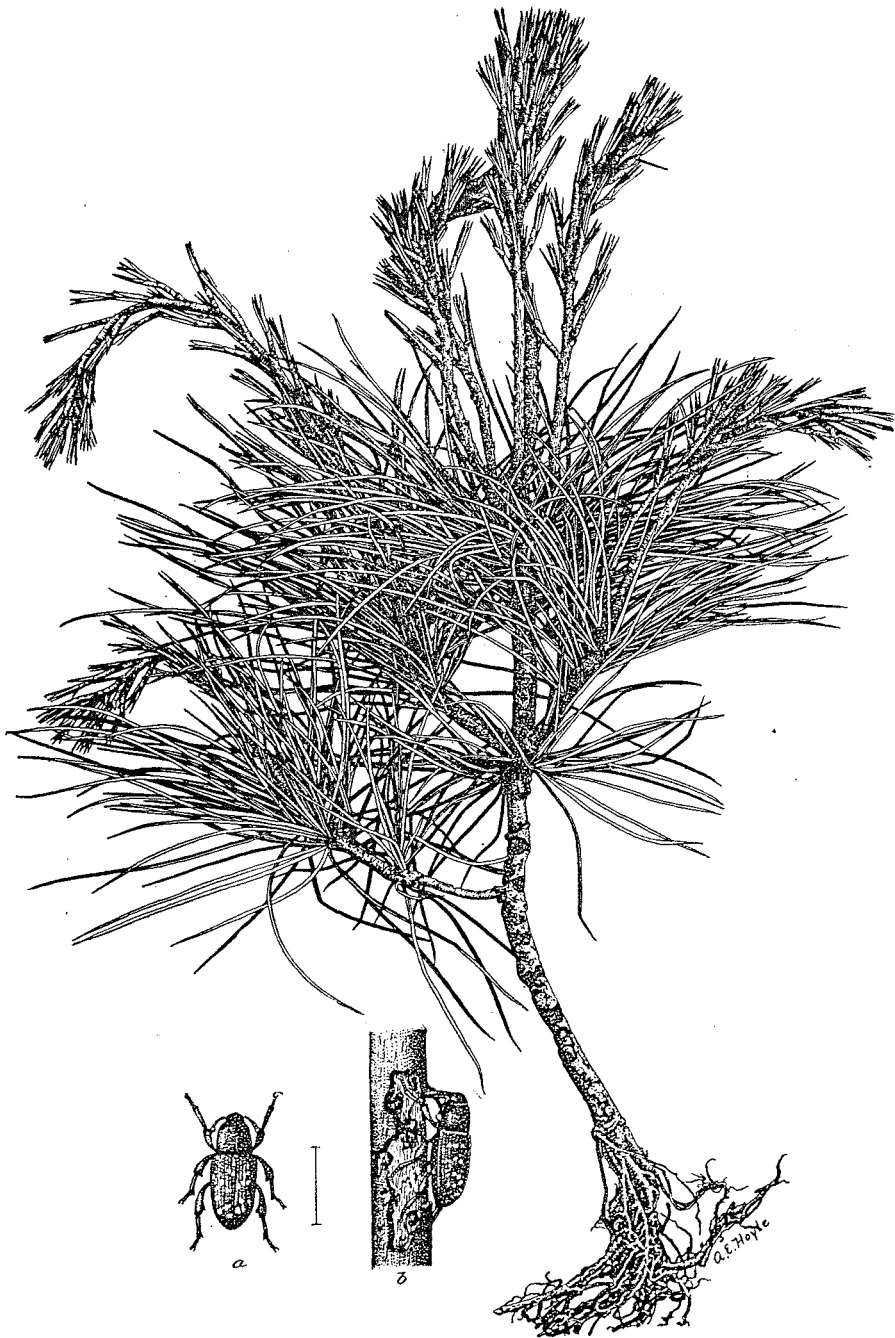
INSPECTION RECORD OF WHITE PINE PLANTATION G. HARVARD FOREST.
 PETERSHAM, MASSACHUSETTS



natural reproduction on wood lots in Sagadahoc county, Maine, showed heavy losses in the first and second summers following cutting, amounting to 20 per cent killed and an additional 25 per cent injured by October of the first year, and the finding of dead two-year-old natural seedlings is difficult, so these percentages are certainly conservative. Specimens of the beetles were taken in Maine, and identified by Professor Brues. It will take time to determine whether conditions in 1913, 1914, and 1915 in New England were unusually favorable for an epidemic of *Hylobius pales*, but in view of the many past failures to save pine reproduction, natural or artificial, on cut-over pine lands, it seems doubtful whether the conditions in those years were abnormal.

Of course, check tests were established on the Harvard Forest in 1915, partly for the purpose of determining at what season the damage began. The planting of the remainder of the area partly covered in 1914 was completed. The deaths from beetle work amounted to 17 per cent by September, with another 18 per cent attacked, but not yet killed. This was the second year after cutting, and there were almost no coniferous trees on the planting area to serve as food during the first year. Another area cut over in the winter of 1914-15 was partly planted (363 trees). By June 25, 48 trees, or 13 per cent of the total number planted, had been attacked, and over half of those were almost certain to die. On still a third area, cut over partly in the winter of 1913-14 and partly in 1912-13, an inspection on June 25, one month after planting, showed 27 per cent attacked, with some already dead. I have been informed that this plantation lost about 30 per cent of its number during the year, although 1915 was a year when drought did no injury to plantations in Massachusetts.

Another phase of the problem presented by *Hylobius pales* is the presence of advance growth in fields or pastures which it is proposed to plant with coniferous stock, especially white pine. When these scrubby, potential "wolf trees" were cut out of such planting areas on the Harvard Forest in the spring or fall preceding planting, the pines planted within 10 to 15 feet of the leeward side of those stumps, and often some trees on the windward side, were almost sure to be attacked by the beetles. Around one stump, less than 5 inches in diameter and only 6 inches high, the beetles killed four planted Scotch pines. Larger stumps were not always proportionately dangerous; but the data shows that all freshly cut pine stumps are distinctly a menace to the forester's ideal of an evenly spaced stand. No damage around these sappy, quick-rotting stumps was noted in the second year after cutting, but the damage the first year was often enough to cause a noticeable blank in an otherwise excellent plantation.



*White-pine seedling, in fifth growing season from seed, girdled by *Hylobius pales**

(About $\frac{3}{5}$ natural size)

a. *Hylobius pales*. ($1\frac{1}{3}$ natural size)

b. *Hylobius pales* feeding. ($1\frac{1}{3}$ natural size)

From what has already been said, it may be judged that the damage caused by these beetles is confined to relatively small trees. The beetles apparently prefer bark covering wood grown during the previous summer or the second previous summer, which makes them especially dangerous to white-pine planting stock of the sizes and ages most commonly used. They do not, however, confine their attacks to trees of these sizes or to bark covering wood of these ages. A few natural seedlings germinating in the spring following cutting were attacked and killed by these beetles during the fall of the first year, although others were not attacked under similar conditions. Similarly, trees older than 3 years were frequently damaged, and sometimes killed. One white-pine tree nearly 3 feet high, showing 7 annual rings at the ground, was found girdled with beetles still at work on it. Natural seedlings up to 18 inches tall on the edges of cut-over pine stands were frequently found dying or to have been killed as the result of girdling by these beetles; but two or three-year-old seedlings of normal growth suffered more severely than larger trees, since the removal of a small volume of bark from their stems proves fatal.

Serious damage, likely to cause the death of the tree, appears to be confined to trees under 3 feet high, but twigs of larger trees, especially of white pine, pitch pine, and hemlock, were repeatedly found to have been attacked by these beetles, and in some cases to have been killed. In one case a dense group of white pines 30 to 40 feet tall, but of too small diameters to be merchantable, had been left in the middle of a pine wood lot which was otherwise cut clean. Many small twigs on these trees were killed by the beetles. It is easy to attribute the injury to these twigs to the sudden exposure of the ground and the crowns to light and wind, and some of the injury was probably caused by this exposure. Definite cases, however, where the two or three-year-old bark on the limbs of white pines up to 18 inches d. b. h. had been partially or wholly removed were found in the course of the investigation of the work of *Hylobius pales*, both in Massachusetts and in Maine. Similar injury has been observed elsewhere, although probably due to some other species of snout beetle than the one under discussion.

As has been stated, the injuries due to the work of *Hylobius pales* were first noted on white pine. The adult form of this beetle, however, is not fastidious in its choice of food. Apparently the bark on two or three-year-old stems or twigs of most conifers is relished. During the investigations of the extent of injury done by these pests, the beetles were collected in the act of feeding on three pines, *Pinus rigida* Mill., *Pinus sylvestris* L., and *Pinus ponderosa* Laws, in addition to *Pinus strobus* L.; on *Abies balsamea* Mill.; on *Picea abies* (L.) Karst. (*P. excelsa* Link.);

and on *Pseudotsuga taxifolia* (Lam.) Britton. Equally conclusive to those who were engaged on the study was the presence of characteristic injury on the stems or twigs of trees and the finding of *Hylobius* beetles resting on or in the ground at the bases of the trees. This occurred hundreds of times on trees of all sizes, from two-year-old seedlings up to open grown trees 18 inches d. b. h., and the beetles so secured were identified with those collected on the same areas in the act of feeding. This combination of characteristic injury and the finding of beetles at the bases of the injured trees was observed with all the species previously mentioned, and also with *Pinus resinosa* Ait., *Larix laricina* (Du Roi) Koch., *Tsuga canadensis* (L.) Carr., and *Juniperus communis* L. Characteristic injury was repeatedly observed on *Picea rubra* (Du Roi) Dietr., and in one case on *Larix europæa* De., but no beetles were collected either on the stems of the injured trees of these species or at their bases. There can be little doubt that these species are acceptable as food to the *Hylobius* beetles; but proof to the same extent as with other members of the same genera previously mentioned can not be presented at this time. No opportunity presented itself to determine whether the beetles would attack *Juniperus virginiana* L., the only other common conifer in central Massachusetts.

One conifer growing abundantly in southern Maine appeared to be rejected by these beetles, since it was found to be uninjured when growing in the vicinity of freshly cut pine stumps and in mixture with injured or killed balsam fir, white pine, red spruce, and eastern larch. This was eastern white cedar, *Thuja occidentalis* L. A further test of the immunity of this species was made on the Harvard Forest in 1915. In the spring of that year half a dozen scrubby white pines, 6 to 10 inches d. b. h., were cut in an old field. Around some of the stumps of these trees three-year-old *Thuja* seedlings were planted in a circle, with white pine, Norway pine, Douglas fir, or western yellow pine outside the circle of cedars. Around other stumps pines only were planted. The beetles promptly attacked all species except the cedar, and usually took the nearest trees except where cedars were nearest. Here, again, beetles were collected in the act of feeding, and identified by Professor Brues. It would therefore appear that *Thuja* alone, of all the coniferous species observed growing in the vicinity of fresh-cut pine stumps in southern Maine and in central Massachusetts, is immune to the attacks of *Hylobius pales*.

The extent to which different species of young coniferous trees of the sizes used in planting suffer from the attacks of these beetles appears to depend chiefly upon the character of their bark. White pine and balsam

fir have tender, thin bark, and a single beetle can eat off enough bark to kill a two or three-year-old seedling in a few days. Pitch pine, Scotch pine, and western yellow pine have a relatively thick, heavy, rough bark, and possibly the greater amount of pitch produced by these species when wounded may retard the activities of the beetles somewhat. At all events, in the areas under observation these rough-barked species were killed more slowly under similar conditions of exposure to attack than white pine or balsam fir, and it is probable that under given conditions a smaller number would be killed than would be the case with white pine. Norway spruce appeared to be more resistant than white pine or balsam fir, but less so than the rough-barked pines. In one plantation of Norway spruce on stump land a loss, attributable to these beetles, of about 25 per cent occurred in the first year, and many more trees were injured, but were able to recover later. If the record of the 109 spruces planted on the edge of the pine plantation first described is taken by itself, the conclusion might be drawn that the beetles do little damage to Norway spruce, and prefer pine bark for food, since only two of the 109 trees had been killed by the beetles at the end of the second growing season, and only 7 others had been seriously injured. This slight loss, compared with that in the adjoining white pine, may have been due in part to a preference for pine bark on the part of the beetles; but in view of the heavy loss in other spruce plantations in mixture with or adjoining white pine, it seems more likely that the location of these spruces in the partial shade of an adjoining stand, and on the windward side of the cut-over area, played a more important part in the lack of serious damage. It should also be noted that the spruce was very thrifty 2-2 stock when planted, and individual trees were able to recover after the removal of an amount of bark from their lower stems which would have killed a three-year-old white pine. Under more normal conditions the loss of Norway spruce was sufficient to make the planting of this species on freshly cut-over pine land of very doubtful advisability.

Unfortunately it is impossible to present at this time a complete series of observations to determine how long after the cutting of a pine stand damage to reproduction on the same area may be expected to continue. The data heretofore presented shows that heavy damage, sufficient in extreme cases to ruin a plantation, has occurred the second year after cutting, and there are some indications that, if planting is deferred until the third season after cutting, some damage may occur. On the other hand, a plantation established in the spring of 1914 on land stripped of a heavy pure stand of pine in the winter of 1910-1911 was unharmed, although all other conditions were favorable for the development of

beetle injury, and natural reproduction had been injured in 1914 on a more recent cutting area within a quarter mile of this plantation. The indications are, therefore, that it is safe to plant the fourth year after cutting, but very unsafe to plant the second year after cutting. No conclusive data is as yet available in regard to the safety of planting the third season after the removal of a pine stand.

The more important conclusions which may be drawn from the foregoing data are:

(1) It is a waste of money to plant cut-over pine lands during the first two seasons after cutting if the coniferous species most commonly planted in New England are used. It may be expected that such plantations will be subject to heavy loss, in some cases amounting to almost complete destruction, from the attacks of *Hylobius pales*. It is probably safe to plant in the fourth growing season after cutting, but in most cases where the establishment of coniferous reproduction is so long delayed hardwoods will have occupied the ground and will have made strong growth.

This conclusion is in accordance with the practice in many parts of Europe, although the species, and even the genera, of both trees and insects are different from those in New England.

(2) Planters should be cautious about cutting out advance growth of pine in pastures or fields in New England when planting coniferous stock. More or less loss around the stumps of the trees so cut is almost certain to occur. If the advance growth can not be removed two or more years in advance of planting, it would probably be better to leave the advance growth and make early thinnings to prevent the development of wolf trees.

(3) The injury done by *Hylobius pales* is an added argument against the use of the shelterwood method in attempting to secure pine, either in pure stands or in mixture with hardwoods, after the cutting of an old stand of pine. The final cutting after the pine reproduction has started merely invites the destruction of the small trees by the beetles. This is, of course, merely an additional difficulty in the use of the shelterwood method, and is, under the conditions cited, no more important than the difficulties found in practice due to the almost inevitable abundant reproduction of hardwoods.

(4) Injury to pine reproduction may be expected as a result of attempts to reproduce a pine stand by cutting in strips, especially if the strips progress from the leeward to windward. In the investigations here reported, damage to pine reproduction was almost invariably found on the leeward side of a freshly cut-over pine stand, sometimes extending

as far as 100 yards from the edge of the old stand, but usually confined to the first 50 yards if reproduction was abundant. If the strip method of reproduction is used, the intervals between the cutting of strips should be sufficiently long for the reproduction to have reached a height of 3 feet or more before the timber on the next strip is cut.

The writer wishes to express his deep appreciation of the assistance given by Professor Brues in identifying the beetles collected in the field work here reported and of the helpfulness of Prof. R. T. Fisher, of the Harvard Forest School, throughout the work.