absorption. Failure to germinate may depend upon chemical changes which proceed at a slower pace, or upon immaturity of the embryo.

The effect of different germination temperatures was investigated by incubating 3×100 seeds each on agar in petri dishes at 25°-32°C., 24°C. constant, and 15°-20°C., one series without stratification, and another series of the same number of seeds after stratification. Both treated and untreated seed germinated most rapidly and completely at 24°C. Tests were run for six months without germination being completed. In one case 76 per cent of the sound seed germinated in 80 days.

Germination was studied in Jacobsen and Stainer germinators, on agar, sand, peat and filter paper in petri dishes, in soil flats and in nursery beds. Best results were obtained on agar. Soil flats and field tests were subject to undetermined temperature and moisture fluctuations. Relatively good germination was obtained in the nursery, possibly just because of these fluctuations in moisture; it is indicated, at least, that hemlock seed are sensitive to injury from excess moisture.

While the exact cause of sluggish germination was not made apparent from these tests, it is probable that differences in the degree of maturity of different crops, or previous treatment of the seed during collection, extraction and storage may be partly responsible for the erratic germination of this species. Unfortunately lack of space prevents publication of the detailed tables of results.

HENRY I. BALDWIN,
N. H. Forestry Dept.

THE DEVELOPMENT AND CONTROL OF PINE BEETLE EPIDEMICS

While the development and control of western pine beetle infestations in virgin, mature ponderosa pine timber have been widely discussed for many years, but scant attention has been paid to the possibility of infestations in the reserve stands of thrifty young trees that are left by the most approved selective logging methods as practiced on national forests and Indian reservations.

Foresters have assumed that the preferred hosts of the beetles are largely the mature and over-mature trees of slow growth and that beetle loss and control problems will largely disappear with the harvesting of this mature timber. Such is undoubtedly the case under ordinary conditions, but during the past year (1932) a situation developed in the reserve stands of ponderosa pine on the cut-over lands of the Klamath Indian Reservation in southern Oregon that furnishes abundant proof that the beetles are sometimes sufficiently aggressive and abundant to attack and kill large numbers of the thriftiest young trees.

The reserve stands in question occur on approximately 39,000 acres of cut-over land, situated in what are locally known as the Solomon Butte and Mt. Scott units. These units are on the eastern slopes of the Cascade Mountains and a few miles distant from the famous Crater National Park.

DESCRIPTION OF THE CUT-OVER LANDS

These cut-over lands are largely surrounded by pure stands of lodgepole pine (*Pinus contorta*). Some virgin ponderosa pine timber forms part of the south and west boundary. The topography is characterized by low, rounded buttes and gently sloping ridges. The soil is a deep volcanic pumice with infrequent rock outcrops. The range in altitude above sea level is from 4500 to 5600 feet.

The reserve stand consists principally of the ponderosa pine (*Pinus ponderosa*) in mixture with the sugar pine (*Pinus lambertiana*), white fir (*Abies concolor*), incense cedar (*Libocedrus decurrens*), and

Douglas fir (*Pseudotsuga taxifolia*) on the higher ridges and buttes. The reserve stand is quite uniformly distributed and has an average merchantable volume of approximately 3600 board feet per acre of ponderosa pine alone. The great majority of the ponderosa pines are of the "bull pine" type, with sharp pointed crowns, long dark green needles and rough, dark bark. Practically all the trees fall in Dunning's tree classes 1, 2 and 3.

It would be difficult to find more ideal growing conditions for ponderosa pine in southern or eastern Oregon. In spite of the series of dry years that has prevailed for the past decade, the ground cover consisting of bitter brush (*Pershia tridentata*) at the lower elevations, and snow brush (*Ceanothus velutinus*) and Chinquapin (*Castanopsis chrysophylla minor*) at the higher elevations, is being rapidly overtopped by a dense growth of subsequent ponderosa pine reproduction over much of the area. Seedlings with leaders from eighteen inches to two feet in length are a common sight. The excellent timber growing quality of this land is further attested by the average cut of ponderosa and sugar pine of 17,325 board feet per acre when the mature timber was logged. A ponderosa and sugar pine cut of 15,826,340 board feet, Scribner Decimal C Rule, was made from one 640 acre section.

CHARACTER OF THE INFESTATION

Before 1931 the chances of the beetles ever reaching an epidemic status in such thrifty fast growing timber seemed remote. Indeed, the beetles remained endemic on the area for a number of years prior to 1931 while at the same time they were severely damaging near-by ponderosa pine timber over large portions of the Klamath Reservation and the Klamath Basin.

In April, 1931, a northeast wind of tremendous violence uprooted and broke thousands of trees on the exposed ridges and slopes of the cut-over lands. Most of the uprooted trees still had enough roots attached to the soil to keep them green until late in the summer, but they were in such a crippled, dying condition that they proved to be enticing bait for the pine beetles. This great abundance of slowly dying trees, together with the warm, dry summer and fall of 1931, enabled the beetles to breed up to enormous numbers before cold weather set in. By that time practically every windfall had been attacked.

The top sides of the logs were attacked by the Oregon pine engraver (*Ips oregoni*) and by the pine flat-headed borer (*Melanophila gentilis*) while the under and shaded sides of the logs were attacked by the western pine beetle (*Dendroctonus brevicomis*) and the mountain pine beetle (*Dendroc-*

TABLE 1

AN ANALYSIS OF INSECT LOSSES

(Data taken from infested pines marked for treating on 29,477 acres of cut-over land, Solomon Butte and Mt. Scott areas, Klamath Indian Reservation, Oregon, fall of 1932.)

Species of pine attacked	Cause of death	Number of trees treated	Per cent of total number of trees treated	Average d.b.h. in inches	Board feet volume treated	Per cent of total board foot volume treated	Average No. of trees treated per section
Ponderosa	D. brevicomis	1568	46.0	18.1	624,556	54.8	34
Ponderosa	Ips & flatheads	214	6.3	15.5	54,904	4.8	5
Ponderosa	D. monticolae	1514	44.4	15.5	373,190	32.8	33
Sugar pine	D. monticolae	112	3.3	20.6	86,936	7.6	2
Totals and averages		3408	100 0	16.9	1,139,586	100.0	74

tonus monticolae). While it was apparent that each windfall supported only a light brood of the western or mountain pine beetles, the windfalls themselves were so numerous that in the aggregate they contained a vast horde of the insects.

The unusually heavy precipitation of the winter of 1931-1932 was so favorable for tree growth that it was thought the beetles would make no headway in the standing green trees. However, as the summer advanced, large groups of trees in the vicinity of the previous year's windfalls began to fade and die from beetle attacks. Groups of ten to fifteen thrifty, vigorous trees with breast high diameters ranging from ten to thirty inches, were frequently successfully attacked.

As soon as it became evident that the beetles were making such a successful, aggressive attack on the reserve stand, it was decided to concentrate control efforts on the most valuable of the cut-over lands. Accordingly, during the fall season of 1932, a control project, covering 29,477 acres of cut-over land of the Solomon Butte and Mt. Scott areas and 4730 acres of adjacent badly infested mature timber, was carried out from two strategically located 20-man control camps. A total of 4375 trees were treated by the peel and burn method, at an approximate cost of $5.12 per tree. All of the laborers employed were Klamath Indians.

THE AMOUNT OF THE BEETLE DAMAGE

The species, cause of death and diameter of each infested pine were recorded at the time the trees were marked for treatment. Unfortunately no crown classification of the trees was made. These data appear in summarized form in Table 1. The table shows the average diameters of the insect-killed trees, and the amount of damage caused by the more important insects.

Because of its ability to complete two generations in one year, the western pine beetle caused a much greater amount of damage than the table indicates. The trees marked for treating in the fall of 1932 represent only part of the 1932 beetle damage since beetle-abandoned trees are not included in the tabulation. It was easily evident in the field that the western pine beetle successfully attacked trees of all diameter and crown classes—from slow growing, suppressed trees to fast growing dominants and co-dominants. Not a single ponderosa pine was found that had successfully repulsed the attacks of these beetles.

The Ips and flathead beetles caused a negligible amount of damage on the Solomon Butte and Mt. Scott area. However, on other cut-over lands of the Klamath Indian Reservation, they have killed almost as much timber as the western pine beetle.

The successful attacks of the mountain pine bettles were largely confined to the smaller, slower-growing suppressed and intermediate ponderosa pine and sugar pine. Hundreds of thrifty trees successfully repelled the attacks of these beetles by copious pitch flows. The sugar pines were attacked exclusively by this insect.

PROBABLE FUTURE TREND OF THE INFESTATION

A large precentage of the beetles were winter-killed in December, 1932 and February, 1933, during two extremely cold periods of several days' duration, characterized by minimum temperatures ranging from 20 to 30 degrees F., below zero. An analysis of thirty-seven samples of bark of varying thicknesses, by the Forest Insect Field Station, Bureau of Entomology, U. S. Department of Agriculture, at Portland, Oregon, showed that 89.6 per cent of the average western pine beetle larvae had been winter-killed. This remarkable and unusual winter-killings may bring this epidemic to an end. If moisture conditions favorable for increased tree vitality continue and no additional windfall takes

place, it is reasonable to assume that there will be a cessation of insect losses on these areas for some time.

CONCLUSIONS AND RECOMMENDATIONS

It is apparent that the aggressive nature of the western pine beetle has not been fully appreciated. When climatic factors are favorable, and when a large amount of fresh windfall is on the ground, they are able to rapidly increase in numbers and can successfully attack and kill thrifty, fast growing ponderosa pines above ten inches in diameter. It is also clear that recommendations to timber-markers, regarding the classes of trees to leave, are difficult to make in face of the fact that the western pine beetle will successfully attack all crown classes and all diameter classes above ten inches.

When marking trees for logging in a badly infested body of timber, the writer believes that most of the "bull pines" of merchantable size should be taken, unless provisions are made for such control work as may prove necessary after logging operations. No changes seem desirable in the present marking practice when marking lightly infested timber.

Foresters should understand the conditions that are favorable for bark beetle development and should learn to recognize incipient infestations. Warm, dry summer seasons and mild winters are ideal for the rapid building up of infestations. Under such conditions, a bad windthrow is sure to be followed by beetle trouble.

The writer's experience leads him to believe that the following measures will help to prevent the buiding up of an epidemic infestation when a bad windthrow occurs:

1. Buck up each windthrown tree close to the root-collar. This will stop the flow of sap from the roots which are still functioning, and will greatly shorten the length of time that the trees are desirable breeding places for tree-killing insects.

2. Lop off the branches of the windthrown trees. This procedure will expose much of the bark to the direct rays of the sun and will discourage attacks in such bark by the western pine beetle and mountain pine beetle.

HAROLD WEAVER,
U. S. Indian Service.