otherwise excellent selections would require re-
habitation by stand improvement and supple-
mentary restocking. Even virgin stands call for
reconstruction with regard to distribution of
age classes. Allowing 20 years to put an in-
tensive management program into full operation,
at least 50 more years must elapse before the
managed forests can begin to produce new tim-
ber on a scale commensurate with their ca-
pacity. Meanwhile, old-growth timber must
necessarily supply most of the market demands.
The source of logs will recede farther and farther
into the hinterland. Logs will be hauled 100
miles or more by truck or over special railroads,
unless mills are moved closer to the woods. As has
been pointed out, the latter alternative is only a
casual remedy to the transportation problem,
and it can be achieved only at a human sacrifice
which may far outweigh any saving in dollars.
Whether logs are hauled 100 miles to the mills or
the mills are moved closer to the source of logs,
increased costs are bound to make them-
selves felt in higher consumer prices, which will
in turn result through lower consumption of tim-
ber.

Foresters must decide now what they wish to
be the future course of the forest industry. They
must decide whether it shall include the grow-
ing as well as harvesting and manufacturing of
timber into furniture, plywood, and other forest
products; and whether it shall merely
salvage over a far flung wilderness what nature
cherishes forested areas which regard for quality,
quantity, or location. They may as well dismiss
the illusion that merely light cutting and fire
protection will suffice. They must decide whether
timber crops are to be grown, harvested, and
manufactured under conditions which per-
mit the employment of people living in perma-
nent communities; or whether, with timber grow-
ing left out of the picture, the industry shall
continue as a floating operation, depending on
transport labor living in forest camps, without
the advantages and responsibilities of American
citizenship. Because of existing maladjust-
ments, large tracts of our timber must continue for
years to come; but it lies within the power of present-day foresters to bring about a differ-
et order in the next generation.

Financial returns on the investment required
to place forests under intensive management must
necessarily be delayed until the roads can be
expressed in board feet and lumber grades. In
regions of rapid growth and good markets, re-
turns should begin to materialize in 10 to 20
years; in regions where a large surplus of mature timber remains, divi-
dends will be deferred much longer. The fact
that even under the best of conditions the forest
will be tied up a decade or more will deter the
private investor, and it may be expected to in-
fluence public forestry in some degree. For this
reason, it is wise policy to advance public pro-
grams on a conservative basis, demonstrating
their merits step by step.
The first step is not a drive for money, but a
realignment of forces and objectives. In a
word, timber growing, as distinguished from
other forest activities, deserves increased atten-
tion on part of all agencies which profess to be
practicing forestry. Management which goes
only as far as conservative logging and fire pro-
tection, even though it may comprise all forest
lands in the United States, will not solve the
timber problem, nor will it contribute much to
the unemployment problem. The Knutson-Van-
denburg Act should be invoked on every na-
tional forest cutting area considered suitable for
permanent timber growing, and similar provi-
sions should be applied on other public lands
dedicated to permanent timber production. At
least one-half of all C.C.C. labor in national for-
tests should go into timber stand improvement.
Aside from funds required for purchase of land
and operation of the C.C.C., large public ex-
penditures are not necessary; but one thing that
is necessary is to get out what has been put
seriously thought about silviculture. Timber
management men, administrators, and researches
must come to the belief that the growing,
harvesting, and utilization of timber crops
constitute the backbone of forestry. Special
public agencies have been created for the ex-
press purpose of managing watersheds and graz-
ing lands. Thousands of men outside the for-
tery profession are fitted by training and in-
terest to deal with land problems of the farmer
and stock grower. Management of timberlands,
with the object of supplying the nation with
good timber at minimum cost, is the joint duty
and responsibility of foresters. They will
not fall in this task if they keep their eyes focused
on the main objective, as it has been stated by
Forest Service experts C. A. Burckard (1920) and
C. C. Webb (1927 and 1928). Survey reports by
Enuden (1926-28) and Gibson (1935-35). The data relative to the de-
stroyed mountain pine beetle have been compiled by the young
author, who has conducted the study of the Beaverhead epidemic
for the past six years.

Enuden, J. C. The beetle eats the pine. Amer. For-
est and Forest Life, 31:286-287, Illus. 1926.

A DESTRUCTIVE INFESTATION IN LODGEPOLE PINE STANDS
BY THE MOUNTAIN PINE BEETLE

By JAMES C. EYVENEDEN AND A. L. GIBSON
Bureau of Entomology and Plant Quarantine

This paper gives a brief history of the destruction of standing timber resulting from an epidemic of the mountain pine beetle (Dendroctonus pseudotsugae Hopk. in the Beaverhead National Forest, Mont. During the past decade the outbreak has swept through this area of 5,851,860 acres, killing approximately 3,706,000 trees above 3 inches in diameter. The total loss of merchantable trees 9 inches and above is estimated to be 77.3 percent.

In 1925 the Beaverhead National Forest, in southeastern Montana, was known for its ex-
tensive stands of mature lodgepole pine. To-

day it is known for its forests of dead trees,
which in a few years will become an impenetrable
tangle of fallen snags that will remain a fire men-
ace for several decades. This widespread de-
struction of timber is an appalling example of the
destructiveness of the mountain pine beetle (Den-
droctonus pseudotsugae Hopk.) when it becomes epidemic. The history of this epidemic, which has destroyed stand after stand of lodgepole pine, shows the tremendous force of such outbreaks and illustrates the need for an alerting to the necessity for their prevention.
The first available record of insect damage within this forest reported the occurrence of an outbreak of the mountain pine beetle in the lodge-
pole pine stands on the west side of the Big Hole Basin in 1911. Prompt action was taken against this outbreak, and control measures were con-
ducted in 1912 and 1913. As a result the condi-
tion returned to normal, and no further reports of insect damage were received until the present in-
filtration appeared some twelve years later.

In 1924, during an extensive insect survey of what is now the western portion of the Beaverhead National Forest, a severe epidemic of the moun-
tain pine beetle was discovered on the east fork of the Beaverhead River about fifteen miles south of the territory then being surveyed. Although
crossing infestation against which this project was directed:

| Year | Acre Control | Trees Treated | Cost  
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1928</td>
<td>10,000</td>
<td>5,271</td>
<td>$111,981</td>
</tr>
<tr>
<td>1929</td>
<td>15,000</td>
<td>13,390</td>
<td>$106,980</td>
</tr>
<tr>
<td>1930</td>
<td>30,000</td>
<td>20,000</td>
<td>$98,400</td>
</tr>
<tr>
<td>1931</td>
<td>50,000</td>
<td></td>
<td>$94,000</td>
</tr>
</tbody>
</table>

Had the project been continued, 865,227 trees over an area of 1,934,264 acres would have required treatment in the spring of 1929.

The work in connection with this project was thoroughly conducted, and each year there was practically no infestation left within the areas covered by control. Little apparent benefit resulted from this excellent work, however, for each year the treated areas were heavily reinfested as the beetles moved southward from the Bitterroot area across the Continental Divide, extending the zone of infestation farther to the south and east. The area of infestation is the area covered by control, as well as the fact that in 1926 the beetles had crossed the 12 or more timberless miles of the Big Hole Basin, which lies in the northern portion of the Beaverhead Forest, indicated very forcibly that in formulating the plan of control the powers of flight of the mountain pine beetle had been underestimated.

During the season of 1927 a new source of infestation for the southern areas of the Big Hole Basin was discovered in some severely infested areas along the east side of the Salmon National Forest. These areas extended along the west side of the Continental Divide and bordered the Jackson and Bloody Dick units, and certain other southern units of the Beaverhead National Forest that are not shown in Figure 1. Though the importance of these centers of infestation as a source of reinfection cannot be accurately evaluated, there is reason to believe that they did contribute materially to the infestation on adjacent Beaverhead areas. The source of the Salmon National Forest outbreak is a matter of conjecture, but it was so extensive in 1927 that it could not have originated from the newly developed Beaverhead infestations.

Though in the spring of 1928 the sources of reinfection were recognized as being of such force as to make the continuation of control within the Big Hole Basin a seemingly hopeless operation, the value at stake warranted a final effort to check the southern spread of this destructive outbreak. This final operation was necessarily on a much larger scale than those of the two previous seasons, treatment being extended to all pine stands surrounding the basin. This effort again proved futile, for the subsequent survey, which for the first time was extended into all pine stands of the forest, showed that the treated areas had been more heavily reinfested than ever before and that the infested acreage was materially increased.

The knowledge of the extent and severity of the 1928 infestation within this forest made further control inadvisable, not only on account of the expense, but also because of the near certainty of failure. Though control measures were discontinued, it was hoped that the wide, timberless Beaverhead River valley, which bordered the Beaverhead National Forest on the east, would serve as a barrier to any extensive spread of the beetles to the southeast. In 1930, however, infested areas were recorded on the Sheep Canyon Hills, an area of public domain (not shown in Figure 1) some 55 miles from the nearest Beaverhead infestation, and on the headwaters of Rocktail Creek on what was then the Madison National Forest. In 1931 control measures were instituted within these areas as a means of protecting the valuable timber stands to the south. Though all

known infested areas to the east of this hoped-for barrier were covered by control measures, the effort was again futile, as the beetles apparently continued to cross this timberless area and the following season killed several times as many trees on the treated areas as the number previously treated. This condition seemed to demonstrate the impossibility of preventing the continued southeasterly spread of the epidemic, and all attempts at further control work were discontinued.

Since the beginning of the Beaverhead project in 1929, an annual survey has been conducted to record the development and progress of the infestation within the various areas. The spread of this infestation as it swept across the lodgepole pine stands of the northeast portion of the Beaverhead National Forest is graphically presented in Figure 1. In this figure the annual extensions of this infestation are represented by the dated mandering lines. The status of the 1935 and 1936 infestations within the different units is also shown.

FIG. 1.—Spread of the mountain pine beetle through the northeast portion of the Beaverhead National Forest.

FIG. 2.—The total and annual losses in lodgepole pine stands within the Beaverhead National Forest, 1927 to 1936 inclusive.
crossing infestation against which this project was directed:

<table>
<thead>
<tr>
<th>Year of Control</th>
<th>Acres Treated</th>
<th>Trees Treated</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1928</td>
<td>10,000</td>
<td>2,371</td>
<td>$11,946</td>
</tr>
<tr>
<td>1929</td>
<td>20,000</td>
<td>17,600</td>
<td>$9,600</td>
</tr>
<tr>
<td>1930</td>
<td>20,000</td>
<td>59,900</td>
<td>$9,600</td>
</tr>
</tbody>
</table>

The project had covered 535,227 trees over an area of 1,341,564 acres would have required treatment in the spring of 1929.

The work in connection with this project was thoroughly conducted, and each year there was practically no infestation left within the limits of the area covered by control. Little apparent benefit resulted from this excellent work, however, for each year the treated areas were heavily reinfested as the beetles moved southward from the Bitterroot area across the Continental Divide, extending the zone of infestation further to the south and east. The area annually reinfested was the area covered by control, as well as the fact that in 1926 the beetles had crossed the 12 or more timberless miles of the Big Hole Basin. The area in the northern portion of the Beaverhead Forest, indicated very forcibly that in formulating the plan of control the powers of flight of the mountain pine beetle were underestimated.

During the season of 1927 a new source of infestation for the southern areas of the Big Hole Basin was discovered in some severely infested areas along the east side of the Salmon National Forest. Those areas extended along the west side of the Continental Divide and bordered the Jackson and Idaho River units, and certain other southern units of the Beaverhead National Forest that are not shown in Figure 1. Though the importance of these centers of infestation as a source of infestation cannot be accurately evaluated, there is reason to believe that they did contribute materially to the infestation of adjacent Beaverhead areas. The source of the Salmon National Forest outbreak is a matter of conjecture, but it was so extensive in 1927 that it could not have originated from the newly developed Beaverhead infestations.

Though in the spring of 1928 the sources of reinfestation were recognized as being of such force as to make the continuation of control within the Big Hole Basin a seemingly hopeless operation, the actual amount of control was determined by the extent to which the beetles were able to spread northward. The control program was continued as long as the beetles appeared to be able to spread northward. The area of the control program was decreased in the spring of 1929 as the beetles were apparently confined to the north and east areas. The following season killed several times as many trees on the treated areas as the number previously treated. This condition seemed to demonstrate the impossibility of preventing the continued southward spread of the epidemic, and all attempts at further control work were discontinued.

Since the beginning of the Beaverhead project in 1926, an annual survey has been conducted to record the development of the infestation within the different areas. The spread of this infestation as it swept across the lodgepole pine stands of the northeast portion of the Beaverhead National Forest is graphically presented in Figure 1. In this figure the annual extensions of the infestation are represented by the dotted mineralline. The status of the 1925 and 1936 infestations within the different units is also shown.

Figure 2 shows graphically the total and annual losses in lodgepole pine stands within the Beaverhead National Forest during the years 1927 to 1936, inclusive. It is estimated that a total of 57,125,000 trees 3 inches d.b.h. and over were killed during this period. The greatest loss in one year occurred in 1932, when 17,500,000 trees were killed. The marked decrease in the 1932 attack was in some areas due partially to the lack of host material, but primarily to the mortality in the overwintering broods of the mountain pine beetle caused by unsatisfactory low temperatures. In those areas where an ample supply of host material still existed, the infestation began to rebuild in 1934, and the broods from the 1934 attack were again subjected to similar low temperatures, which caused a marked decrease in the 1935 attack. In 1936 no losses were caused by the mountain pine beetle on any of the forest units, while on the other hand the infestation was materially reduced. In some areas there still remain a rather large number of mature trees; and as in 1937 and 1938 the loss...
festations continued to decrease in severity, a large percentage of them will undoubtedly escape the present infestation.

Though a number of secondary bark beetles are associated with all mountain pine beetles, epidemics of *Pityogenes chalcographus* is, perhaps, the most important, and during the decline of such epidemics it is always responsible for the death of small trees. As there are at least two generations of this insect each season, the green tops of trees killed the previous season by the mountain pine beetle are attacked by the first generation, and the tops of newly attacked trees by the second. Though this beetle played an important role in the destruction of timber on the Beaverhead National Forest, under normal conditions its population would have decreased concurrently with the decrease of the primary insect. In 1933, however, the abnormally sudden reduction in the number of trees killed by the mountain pine beetle materially limited the supply of such host material for subsequent *Pityogenes* attack. As these insects were apparently not affected so severely by the low temperatures, the broods that emerged in 1934 were forced to attack uninjured green trees. Though primary attacks of these beetles are usually confined to trees of small diameter, during this period many large trees were killed. In 1935 and 1936 the losses from *Pityogenes* were as great as in 1934, returned to a status normally characteristic of gradually decreasing mountain pine beetle epidemics. The number of trees killed by this normally secondary insect during the years 1935 to 1936 inclusive are shown graphically in Figure 2.

If we consider the total stand as including all trees of 3 inches d.b.h. and above, the residual stand in 1936 shows an average stocking of 20.7 trees per acre. If, however, only merchantable trees 9 inches d.b.h. and above are considered, the residual stand will average only 3 trees per acre. As the acreage in which these figures included untimbered areas, the number of trees per timbered acre will be considerably higher for some of the areas. The loss varies materially for the different units, depending upon the number of years the infestation has been present. For example, within the units around the Big Hole Basin approximately 90 percent of the merchantable trees have been killed, while on the southern and eastern units this has been less than 50 percent. The total loss of merchantable trees is estimated to be 77 percent of the original merchantable stand. Table I shows the character of the losses in tree diameter classes for the 12-year period 1927 to 1938, inclusive, but includes only those areas of the Beaverhead National Forest which border the Big Hole Basin, or a total area of 543,700 acres. As the infestation was at its height when it swept through these areas, the destruction of timber has been more severe than in other portions of the forest. These figures are shown as a depletion of the maximum seriousness of the outbreak.

Although there was no dislocation of timber-using industries as a result of the epidemic on the Beaverhead National Forest, the killing of merchantable trees has virtually destroyed the potential value of this forest, for as much as 40 percent of the commercial timber is still living, with very light losses from 1936 to 1938. There still remains a fair stocking of pines for which there is a constant local demand, and the cutting of these will be the only timber industry within the forest for many years.

The future of the residual stand within these beetle-killed lodgepole pine forests is problematical. A serious fire hazard has been created which will last for several decades. When fires occur in such areas, they usually develop into serious conflagrations owing to the tremendous accumulations of inflammable material. If fires occur, the residual stand, with additional seeding from the larger trees, will produce a second crop of commercial timber in the shortest possible period of time.

The lesson to be drawn from this situation has to do with its cause rather than with theorizing upon the effect, and emphasizes the fact that forest-managing agencies should concern themselves with the prevention of future bark beetle epidemics. Bark beetles cannot be eliminated from an area, nor can the application of control be considered as a panacea for all future insect problems.
Mountain Pine Beetle

Experiments carried out in New Brunswick over the past ten years by the Dominion Forestry Service of the Canadian Department of Mines and Resources, Ottawa, indicate that the growth of valuable young conifers can be accelerated through killing overtopping hardwoods by girdling. The girdling experiments were initiated in 1926, when two 50-acre areas were established in mixed wood stands with a 10-acre control plot being set aside in each area. Seventy-five percent of the hardwoods present at the time of establishment were girdled. Healthy, well-formed hardwoods of high economic value were left but those, although serving to protect reproduction, have not yet shown any response to release.

At five-year intervals two remeasurement surveys were made, the results of the latest showing that the composition of the stands is slowly changing towards a coniferous type and there are now ample conifers (two thirds of them spruce) to provide a future cut. Growth of the residual conifer stand has increased rapidly as a result of the girdling of the hardwoods, having advanced from 87.6 to 115.0 cubic feet per year on one area and from 33.3 to 57.7 cubic feet per year on the other. On one area there is now sufficient coniferous reproduction to warrant an immediate cut of from 5 to 10 cords per acre, but reproduction is not yet established on the second area.