

**An analysis of the mistletoe problem on ponderosa
pine in the Grand Canyon National Park.**

By

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INTRODUCTION

On numerous occasions concern has been expressed regarding the invasion mistletoe is making in the ponderosa pine stands on the south rim of the Grand Canyon National Park. The problem has been given casual attention by pathologists, members of the Branch of Forestry, and by the protection staff of the Park, but it has never been studied in great detail.

On August 22, 1947, Assistant Chief Forester L. F. Cook, Regional Forester S. T. Carlson, Chief Ranger Perry E. Brown, and the writer again reviewed the mistletoe situation at the Park. At this time it was suggested that the Division of Forest Pathology make a preliminary study for the purpose of determining (1) the need and feasibility for control, and (2) the general principles to be followed if control were practised. This suggestion received approval from the Chief Forester, the Regional Director, and the Park Superintendent. Work was subsequently authorized by Dr. Lee M. Hatcher, Head Pathologist in charge of the Division of Forest Pathology.

With the above-mentioned objects in view, field work was performed from September 30 to October 6, inclusive, with the able assistance of Assistant Chief Ranger W. C. James of Grand Canyon National Park and R. E. Willenbaugh of the Division of Forest Pathology, and with excellent cooperation from Chief Ranger Brown.

In general, the field work fell into two categories, namely, (1) survey of the occurrence and frequency of mistletoe and (2) establishment of sample plots designed primarily to provide specific illustrations of the main problems that will be encountered if control of the pest is undertaken.

The pertinent results of the work were summarized in December 1947 and discussed informally with various members of the Division of Forestry. They were also presented formally to the Protection School held at Grand Canyon in April 1948, at which time the problems were demonstrated in the field. Pressure of other work outside of the Southwest has delayed the preparation of this report.

OCCURRENCE AND FREQUENCY OF MISTLETOE

Three conifers in the south portion of the Park are attacked by mistletoe, namely, Juniper, pinon, and ponderosa pine. The one on juniper is Phoradendron juniperinum a true mistletoe and does not attack pine. It is spread mainly by birds, consequently trees are seldom heavily infested until they have reached a size that would make them attractive as roosting places. Both pines are attacked by species of Arceuthobium, or dwarf mistletoe, which, however, do not cross from pinon to ponderosa pine or vice versa. The dwarf mistletoes produce explosive berries from which the seeds are shot several feet. Once established, these parasites gradually spread to surrounding trees within range, infecting young and old alike. Because of its low dense habit, and generally scattered reproduction, the dwarf mistletoe on pinon is considerably less damaging than the one on ponderosa pine. In addition it is frequently attacked by a fungus disease (Septoglossum) which may decimate its seed crop. The ponderosa pine dwarf mistletoe (Arceuthobium vaginatum f. cryptopodum Gill) has few natural enemies, none of which are serious.

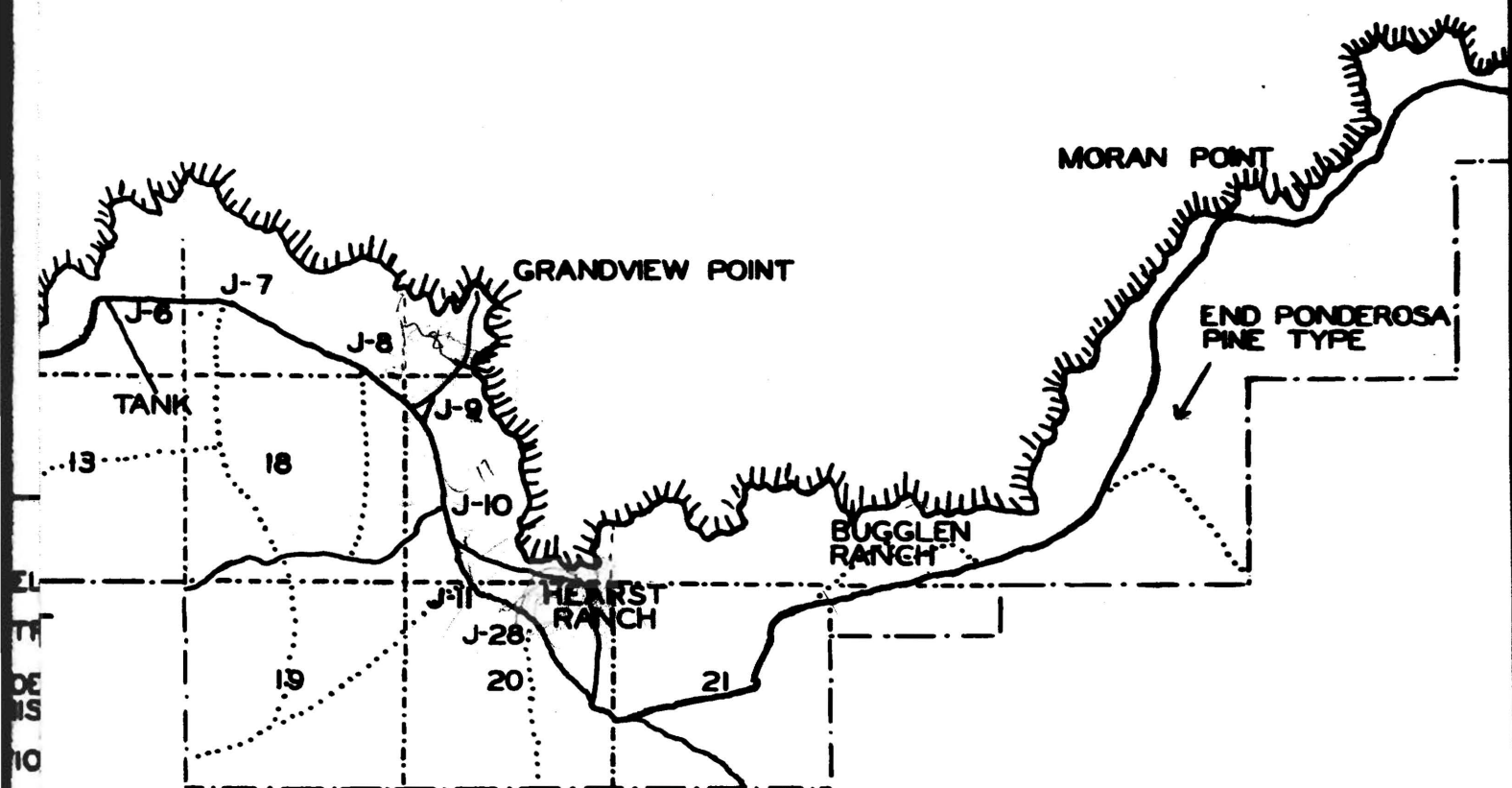
A broad picture of the occurrence and frequency of the ponderosa pine mistletoe was obtained by observations made while traveling the roads of the Park shown in Figure 1. Road junctions were identified by numbers and records of the mileage, together with the degree of mistletoe, were made. Figure 2 illustrates the type of information gained from this survey along each road traveled.

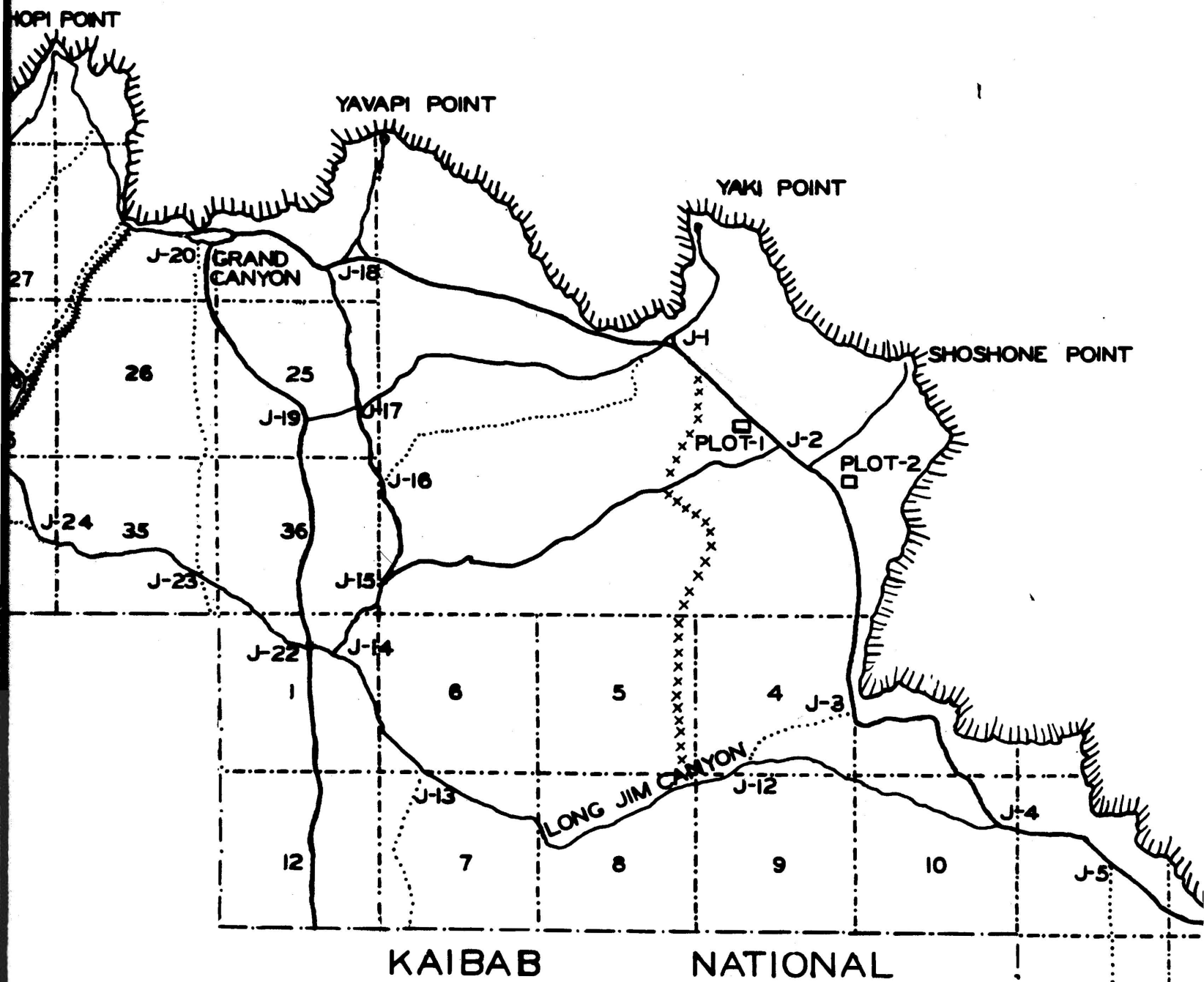
Maps of the two sample plots were developed from bearings and rough measurements using a staff compass. On plot 1 the trees were numbered with aluminum tags to correspond with the numbers shown on the map. It was felt that the tags would aid those who might be interested in reviewing on the ground the problems illustrated by the plots. Plot 2 was so simple that the d.b.h. of the principal trees as indicated on the map will suffice to orient those who might wish to study the area.

The ponderosa pine type within the Park extends from the western edge of the map (Fig. 1) to a point about midway between the Buggalen Ranch and Moran Point where it suddenly ceases in favor of solid pinon-juniper to the east. The area around the Hearst Ranch including Sections 18, 19, 20, and 21 is quite flat and is characterized by an open stand of ponderosa pine interspersed with gambel oak and grass. In general, the pine becomes increasingly scattered as one continues

MISTLETOE SURVEY
GRAND CANYON NATIONAL PARK
SHOWING THE AREA OCCUPIED BY PONDEROSA PINE, PLOT
LOCATIONS, ROUTES FOLLOWED AND PRINCIPAL LANDMARKS

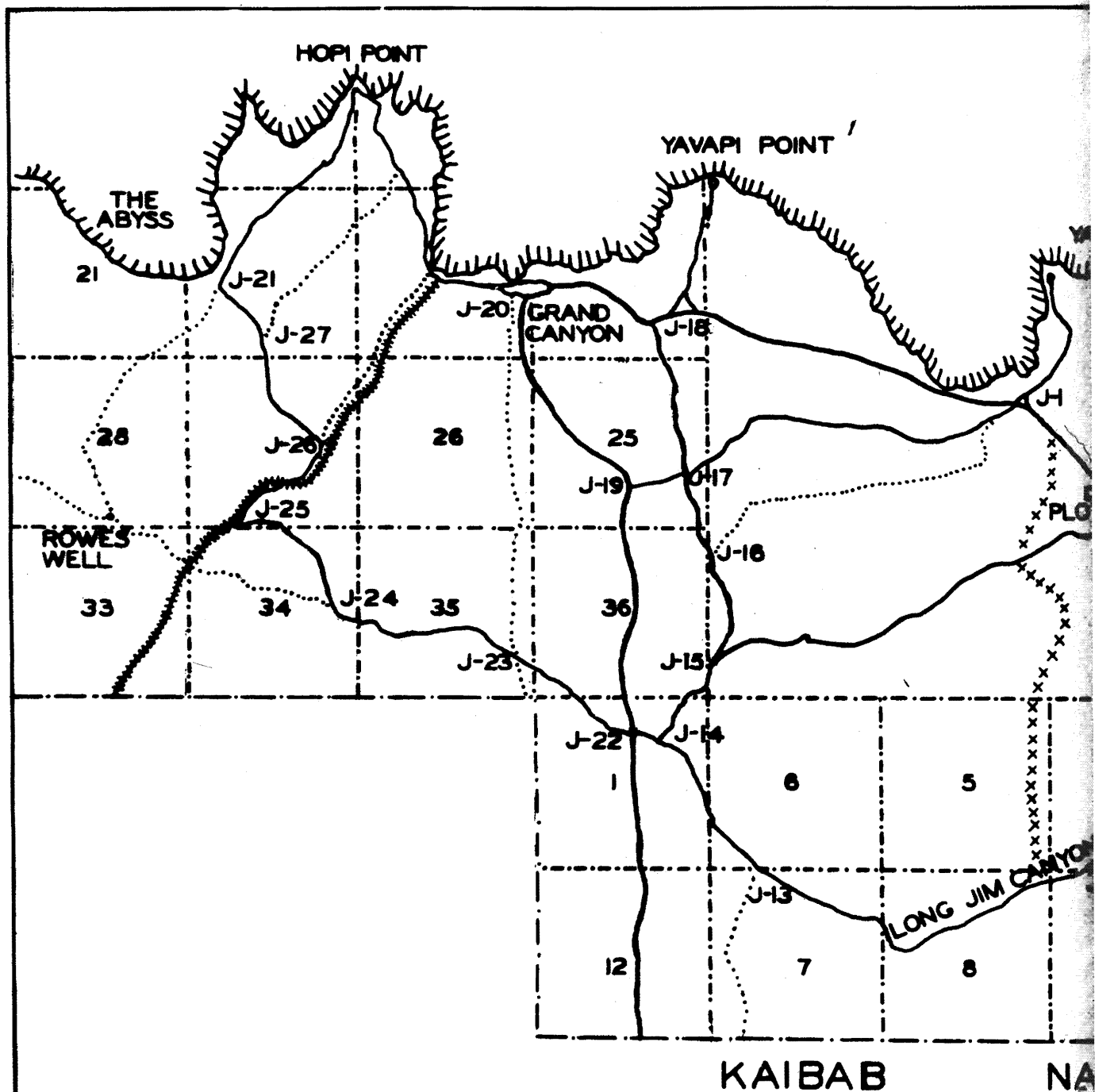
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BY REM. OCT 23, 1947





TRAVELED
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FOREST



LEGEND

- ROADS TRAVELED
- ... ROADS NOT TRAVELED
- xxxx NO MISTLETOE FOUND WEST OF THIS LINE
- J-6 ROAD JUNCTIONS
- ~~~~ CANYON RIM

MILEAGE CHART OF EAST RIM DRIVE GRAND CANYON NATIONAL PARK

SHOWING PRINCIPAL JUNCTIONS AND DEGREE OF INFECTION

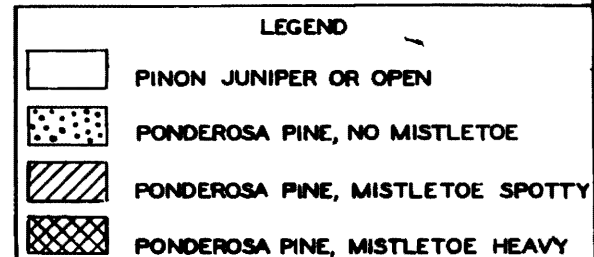
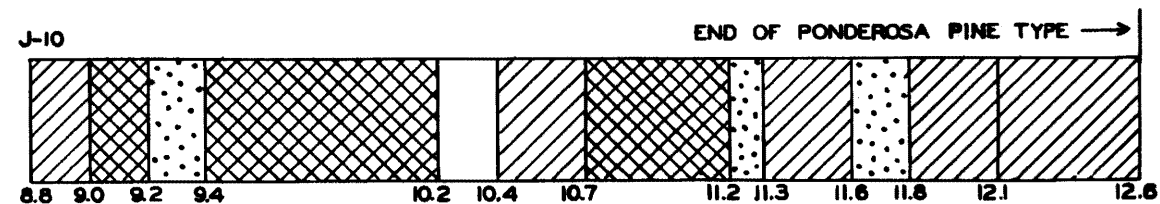
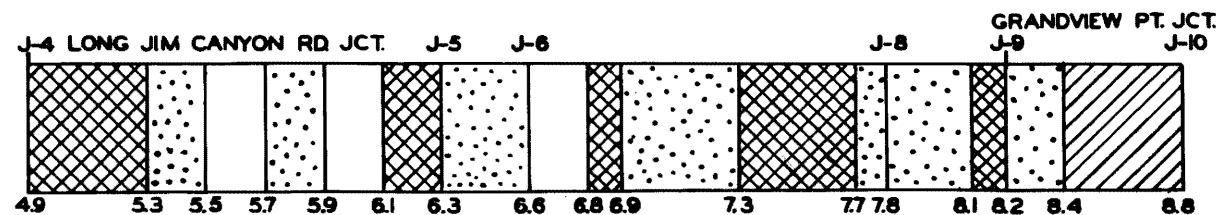
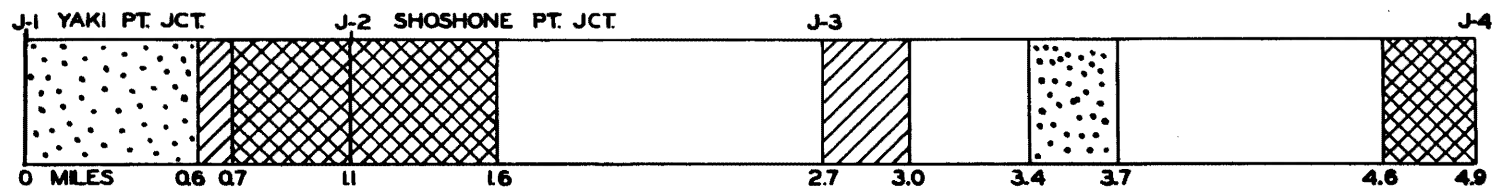


Figure 2.

south from the rim drive. Elsewhere in the Park, ponderosa pine stands are fairly well stocked. They are, for the most part, confined to the canyons or drainage bottoms and are separated by stands of pinon and juniper which occupy the high ground. Only at the Hearst Ranch does ponderosa pine extend to the canyon rim. Elsewhere it ceases a quarter of a mile or more to the south. Pinon and juniper usually occupy the ground immediately adjacent to the rim.

Ponderosa pine mistletoe is as severe in the south portion of the Grand Canyon and the adjoining Kaibab National Forest as in any large area of the Southwest. It appears to have been established longest in the flat terrain south of Hearst Ranch, Sections 18, 19, 20, and 21. (Fig. 1). As previously mentioned, the ponderosa pine in this area is widely scattered and interspersed with oak scrub and grass as shown in Figures 3 and 4. Mistletoe is heavy throughout the area. Dead, dying, and heavily broomed trees are everywhere (Figs. 5, 6, 7, 8, 9, and 10). Hardly a tree over six feet high can be found that does not carry some mistletoe. Reproduction is scarce; and while uninfected seedlings can be found, they are invariably within range of infected overstory trees which means that they will either be killed by the parasite while they are very small or else they will become infested later and live for many years to perpetuate it on their own progeny. It is quite probable that at one time the pine stand in these four sections was much more dense, and that its present open condition can be attributed to gradual killing-out by mistletoe. It is unlikely that mistletoe could have become so thoroughly distributed over such a large area if the stand had not been fairly dense at the time the parasite became established. There is a gradual decline in mistletoe damage both east and west of this ancient infection center. Smaller and more recent infection centers, measured in acres rather than square miles, occur at numerous places along the rim drive and will be discussed in more detail later in conjunction with specific problems concerning control.

East of Grandview point mistletoe occurs quite generally to the edge of the ponderosa pine type. To the west it is common as far as Yaki point. None was found in ponderosa pine west of a north-south line through or near Yaki point. This line is roughly indicated on the map (Fig. 1), as determined from "windshield surveys" and reconnaissance on foot. There is good reason to believe that if the parasite is allowed to go unchecked it will gradually encroach upon the mistletoe-free pine to the west. The encroachment will of course be very slow so there is no immediate cause for alarm. The point should, however, be given consideration in a long range protection program for the Parks.

Figures 3 and 4.—Illustrations of the openings in the ponderosa pine forest south of the Hearst Ranch where ponderosa pine has presumably deteriorated as a result of long exposure to mistletoe and is gradually being replaced by grass and scrub oak.



Figure 3.



Figure 4.

Figures 5 to 10.—Illustrations of the effects of mistletoe on ponderosa pine south of the Hearst Ranch.



Figure 5.



Figure 6.



Figure 7.



Figure 8.



Figure 9.



Figure 10.

MISTLETOE BEHAVIOR

Seeds of the dwarf mistletoes are born in berry-like structures which explode at maturity expelling the embryos (seeds) with considerable force. The mechanism is such that the embryo usually takes off at a sharp vertical angle, the trajectory being similar to that of a mortar shell. The initial upward thrust enables mistletoe, once established in a tree, to continuously encroach upon the growing crown above it. Were it not for this tendency many more infections, especially on small trees, would die as the limbs on which they occurred became shaded out. Those embryos which are not caught in the crown of the tree on which they developed, continue into the air, most of them falling 20 to 40 feet away. Some manage to go as far as 60 feet, but very few go further. For practical purposes it is believed that trees which are 60 or more feet from an infection source are out of danger. There are important exceptions to this rule. For example, if a tall tree with mistletoe in its upper crown were to fall at the time the fruits of the parasite were ripe it could establish infections in trees that happened to be in the area where the infected part of the crown fell. Furthermore, one often encounters isolated mistletoe infections in the midst of forests that show no other indications of the parasite past or present. In such cases it is obvious that the mistletoe embryos were carried long distances by birds or mammals.

In order to start a new mistletoe plant an embryo must alight on a young pine stem before there has been much cork formed by the bark tissues. In nature the suitable points for establishment are limited to the last two years' growth, although the parasite has been successfully started on older growth where the cork had been scraped off. The embryo is covered with a sheath of hygroscopic material which serves the dual purpose of adhering to the medium upon which it alights and of supplying water during germination. If the embryo is expelled during a dry period the viscous sheath dries out completely. During moist periods it absorbs water, forming a jelly-like globule over the embryo. Moisture thus absorbed is retained during subsequent dry periods until long after the surface of a pine stem would be completely dry. Germination occurs when temperature and moisture conditions following dormancy dictate. The viscous sheath protects the delicate rootlet or primary absorbing organ from desiccation while it is making its way from the embryo into the tissues of the host plant.

CONTROL

Methods

At present the only known method of controlling mistletoe is to prune it out or destroy infested trees. The recent work with hormones such as 2,4-D suggests that a chemical method for killing the parasite

without seriously injuring the host might be developed if the demand for control were great enough to justify the necessary investigative work. Thus far all the chemicals that have been tried on a small scale have been unsatisfactory because they have either been innocuous, have injured the host, or have merely killed the mistletoe shoots without harming the absorbing system.

A few diseases are quite destructive to the shoots and fruits of certain dwarf mistletoes, notably those attacking pinon, limber pine, and douglas fir in the Southwest. These diseases, unfortunately, do not affect our ponderosa pine mistletoe which is remarkably free from natural enemies. The shoots of the latter are sometimes attacked by spittle insects and, under stress of hunger, rodents will eat the succulent infected bark. These agents hold little promise for biological control of the parasite.

Pruning and cutting out mistletoe is a slow and expensive process. Furthermore, unless it is carried out in accordance with certain dictates based on peculiarities in the life history of the parasite much effort will be wasted. Certain basic inviolable rules are outlined in the following paragraphs.

RULE 1. Plan on several operations at specified intervals.

The basic fact behind this rule is that mistletoe shoots are not produced for several years after the seed germinate. The initial operation, therefore, is bound to leave a number of infections in the stand which were not visible at the time. These invisible or latent infections will produce their first shoots from one to five or more years after the initial operation, the time being dependent to a great extent on the vigor of the host or host branch on which they occur. In general the more vigorous the host the sooner shoots will develop. Figure 11 illustrates the course of development of mistletoe on a relatively vigorous pine branch, in most cases the interval between germination and production of the first berries is longer than the diagrams indicate.

RULE 2. The interval between operations should not be less than two years.

This will minimize the cost of control. From Figure 11 it will be seen that fruits can not possibly be produced until two years after the first shoots have appeared. Therefore, the infections which were invisible at the time of the initial operation could not initiate new infections for at least two years. Three or, at the most, four operations at two-year intervals should rid

Figure 11.—Diagram showing the development of a mistletoe plant in a pine stem. The "seed" (A) develops into an absorption system (B), shoots (C) are not developed until at least the third year and another year is required to produce flowers (D) which require about 15 months to mature (E). Immature fruits (F) are also shown. The absorption system (black) develops mainly in the pine bark, however those points which touch the cambium become imbedded in the wood as new layers are put on thus forming "sinkers" which superficially resemble medullary rays but which can usually be distinguished in stem cross sections by their lemon yellow color. The first mistletoe shoots usually appear near the point where the stem was invaded by the "radicle" of the "seed."

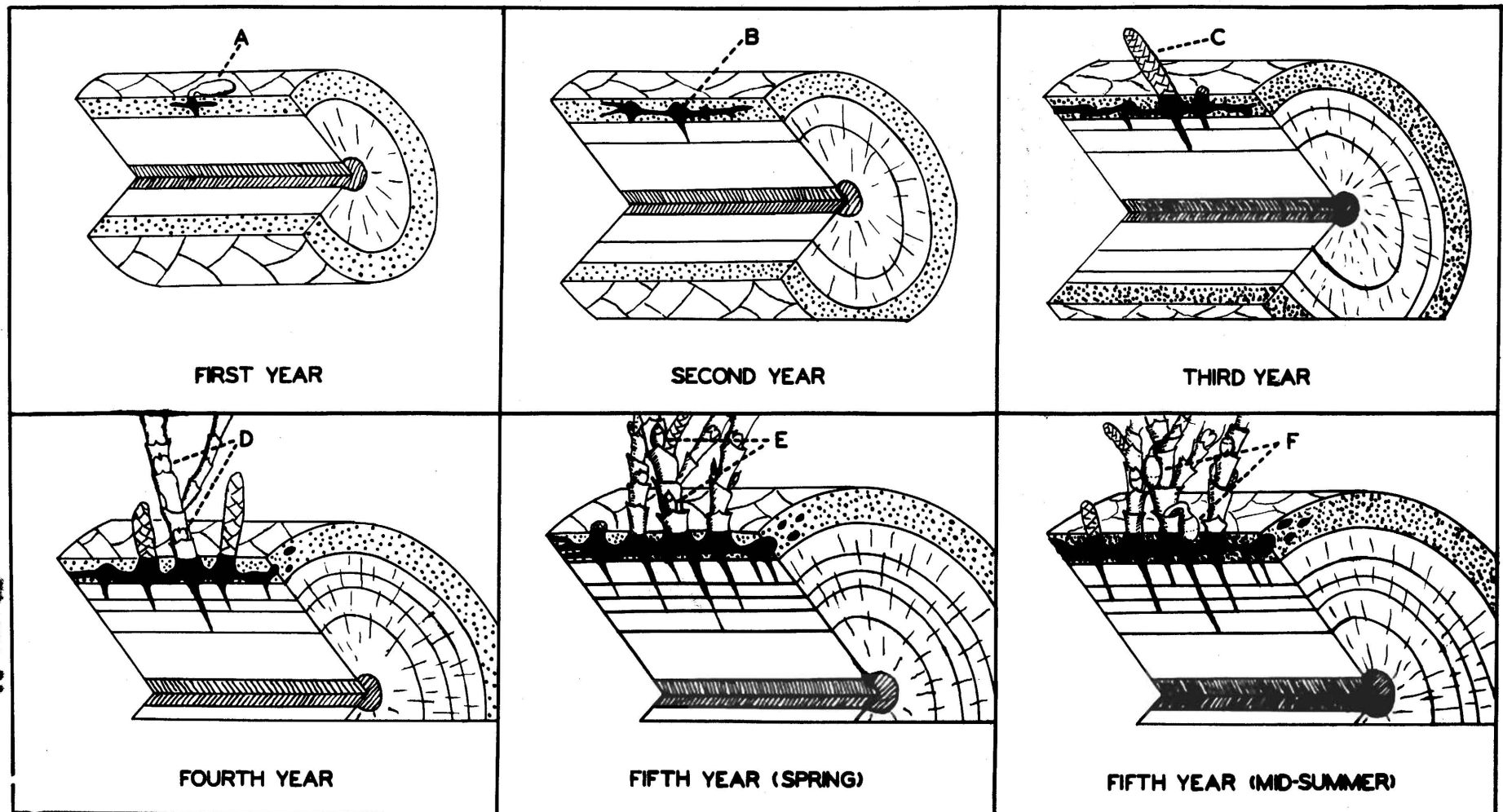


Figure 11.

a stand of mistletoe completely. On the other hand, experience has shown that two operations five years apart will reduce the mistletoe population in a heavily infected stand to the point where it will be relatively harmless for a long period of time. The time interval as well as the number of operations to be accorded any particular stand will depend on the objectives of the control program but in no case should the interval exceed five years.

RULE 3. Control operations should be avoided from mid-July through August.

During this period the fruits are ripe and explosive. The disturbance caused by the control operation leads to the establishment of more new infections than would normally be the case. Falling infected trees is especially bad practice at this time.

RULE 4. Make pruning cuts at least 18 inches behind mistletoe shoots.

This is somewhat a rule of thumb designed to insure the removal of the absorbing system of an infection with one operation. Naturally, the distance the absorbing system extends beyond the shoot varies more or less directly with the age of the infection. On very young branches, 18 inches will be more than ample to insure excision of the absorbing system, on very old ones it will not suffice. Experience has shown that the 18-inch limit can be applied in practice without causing undue damage to the trees and with reasonable assurance that in most cases the absorbing system will be removed. If the absorbing system is left in the branch, the mistletoe infection will continue to grow and produce more shoots as illustrated in Figure 12.

RULE 5. Remove all mistletoe seed sources within 60 feet of trees or stands which are to be permanently protected from infection.

This rule is based on the incomplete results of experiments which indicate very strongly that mistletoe seed are seldom shot more than 60 feet. The greatest chances for infection are among trees 20-40 feet from an infection source. The intensity of the barrage falls off rapidly in the next 20 feet. Beyond 60 feet the chances of infection are negligible.

Objectives of Control and Their Application

Mistletoe control may be aimed at either complete eradication of the parasite from an area or merely reducing its population to the point where it is relatively harmless to the present stand, the future

Figure 12.—Diagram illustrating the relation between the position of mistletoe shoots on a branch with respect to the mainstem and the probable extent of the absorption system. Where the shoots are less than 18 inches from the mainstem the probability is great that pruning will not remove the absorption system and new shoots will subsequently develop at the pruning wound.

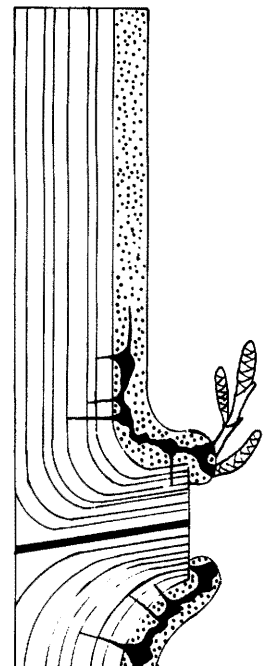
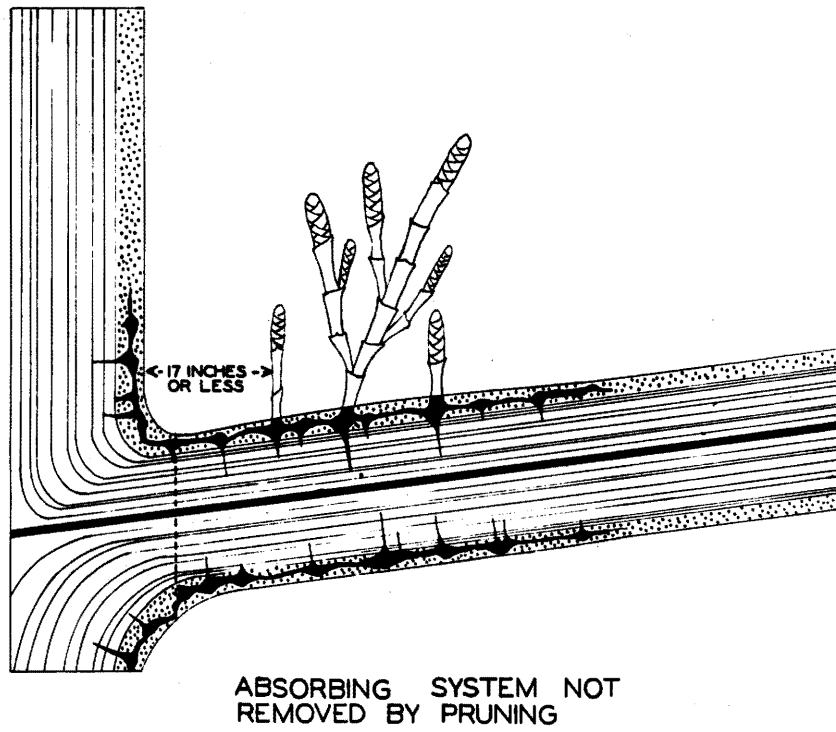
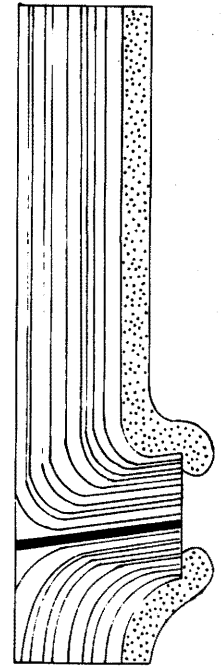
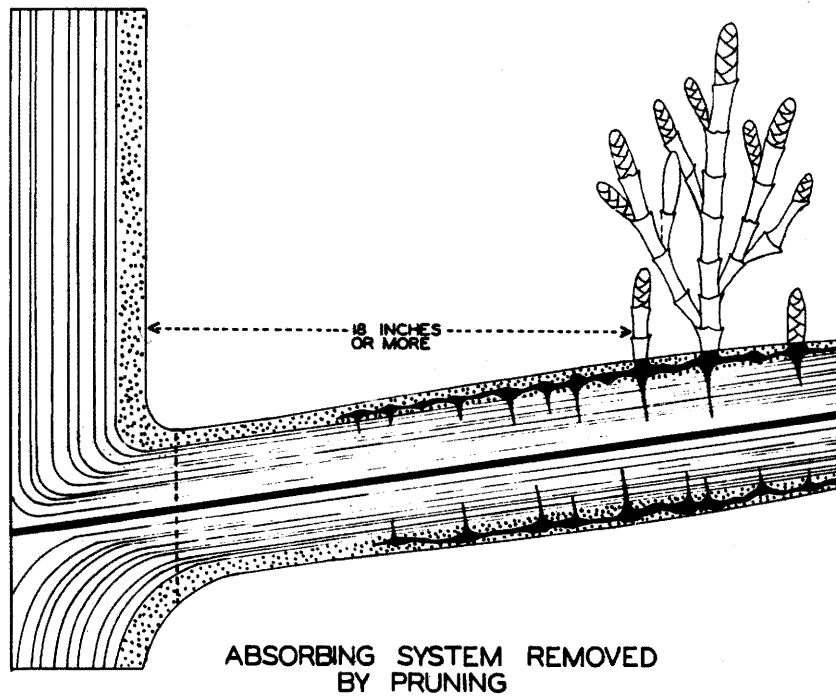


Figure 12.

stand, or both. Graduation would seldom be desirable in a National Park. On the other hand, there may be a definite place in Park protection for reducing mistletoe population in infected areas or preventing it from invading to new localities.

One objective of control would be to reduce the mistletoe population in stands that are now infected. This would be most applicable to relatively young stands where the parasite is not too abundant. Another objective might aim to protect existing mistletoe-free stands which are in jeopardy of infection from adjoining stands. In a third case it might aim to protect future generations from heavy infections in an area infected today.

Numerous cases will be encountered where one objective will partly accomplish others, but it is highly important that the primary one be determined and specified before undertaking any control measures.

Illustrations of Control

Plot 1 (Figs. 13 and 14) illustrates an actual situation in the Park where, if control were undertaken, it would be necessary to decide upon the primary objective before taking action. If a reduction of mistletoe population is desired, the trees indicated by dotted lines on the diagram (Fig. 14) would have to come out and those with parallel hatching would have to be pruned. This would require the removal of many fine old trees near the road. The landscape would be subjected to drastic changes as a result of the operation though in this particular case these changes would not be too unpleasant to the eye. The advantage in this case would be that the area would gradually improve as a result of the action whereas if nothing were done it will gradually deteriorate as the older trees die and the younger ones are killed or malformed by mistletoe. Pinen, juniper, and oak are already well established in the openings to the southeast and the west of the point where the mistletoe-killed saplings are indicated (Fig. 14). It is not at all unlikely that under natural conditions with such heavy mistletoe present that these less aesthetic species will gradually occupy more and more of the ground. Perhaps the immediate sacrifices in trees and aesthetic values are not considered desirable for this type of control. In that case there is an opportunity to protect the good stands of ponderosa pine 100 to 200 feet southwest of the rim drive. Then it would only be necessary to treat the trees which constituted a source of infection to the healthy stands. This would involve getting rid of all mistletoe within 60 feet of the edge of the good stand, as well as cleaning out the small amount of mistletoe that has already invaded it at two small spots. The untreated portion of the plot next to the road would in time deteriorate from the invasions of the parasite and conceivably would reach a degree of ugliness where treatment could be given without sacrificing aesthetic values.



Figure 13.--Panoramic view of Plot 1 from NE corner.

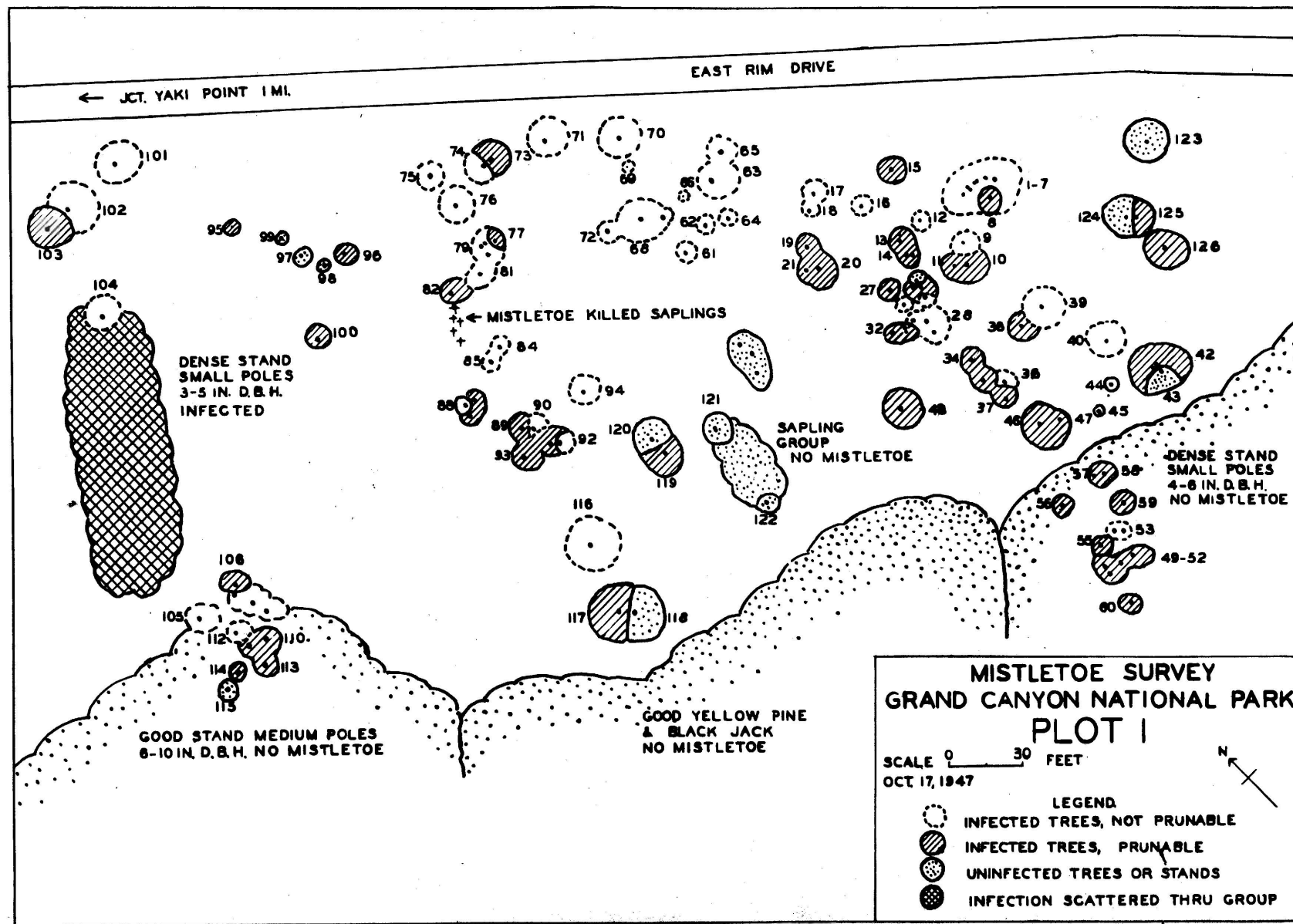


Figure 14.

Plot 2 illustrates a case where control might be warranted for the benefit of future generations. Here there is a patch of young vigorous reproduction (Figs. 15, 16, 17) surrounded by heavily infected old trees the diameters of which are indicated on the diagram (Fig. 17). These, together with a group of heavily infected poles to the southeast preclude the possibility of the reproduction ever amounting to more than a few scraggly mistletoe-infected trees. The parasite is already present on some of the seedlings in the patch. It has also killed a great many seedlings which were in close proximity to the infected overstory trees and were consequently infected at a very early age. The 27-inch tree indicated by a + in Figure 17 has died recently and one or two other large ones apparently do not have long to live but certainly half of them will continue to bombard mistletoe seed on the reproduction below them for the next 20 to 40 years. When they go, the pinon juniper and scrub oak will be on their way in, the ponderosa pine on its way out. Protective control would mean eliminating the mistletoe from the old trees as well as from the group of heavily infected poles. Pruning of the old trees would be very expensive but would be preferable to removal as far as possible in order to provide the best possible seed source for oncoming reproduction.

There are numerous areas of small acreage in the Park where control might be advisable for the purposes mentioned above. The most important of these from the aesthetic standpoint occur along the Rim Drive east of Yaki Point. For example, it might be advisable to apply direct control in the lightly infected area at 2.7 to 3.0 miles as shown in Figure 2 or protective measures might be applied at 6.9 and 7.3 miles in order to preserve the uninfected stand between those points. Certainly the uninfected stand extending from 3.4 to 3.7 miles would warrant frequent inspection and some treatment if mistletoe were found within it. East of J-10 (8.8 miles) the ponderosa pine is either so heavily infected or so open that control would hardly be advisable.

RECOMMENDATIONS

An endeavor has been made here to describe the mistletoe situation on ponderosa pine as it exists in the southern portion of the Park and to call attention to the obvious fact that stands infected with the parasite are bound to deteriorate in the course of time. It was also pointed out that its destructive action is so slow that while certain stands in the Park are severely infected, the need for control cannot be classed as an emergency in any sense of the word.

Figures 15 and 16.—Views of Plot 2 showing the nature of the ponderosa pine reproduction. The 27-inch infected tree (see Fig. 17) appears in the background of Figure 15. In Figure 16 the background trees are those shown in NE quadrant of the plot (Fig. 17).



Figure 15.

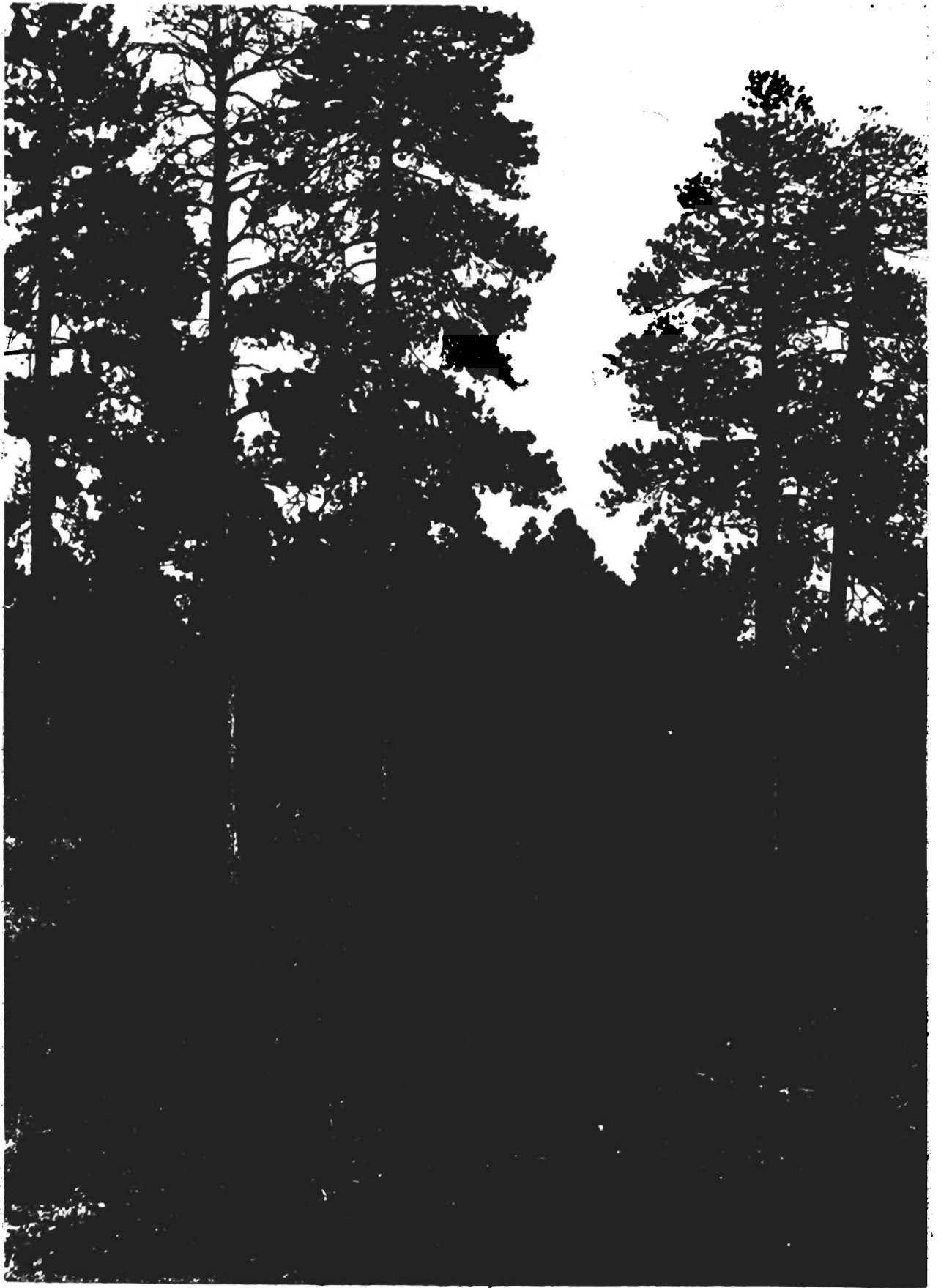


Figure 16.

MISTLETOE SURVEY GRAND CANYON NATIONAL PARK PLOT 2

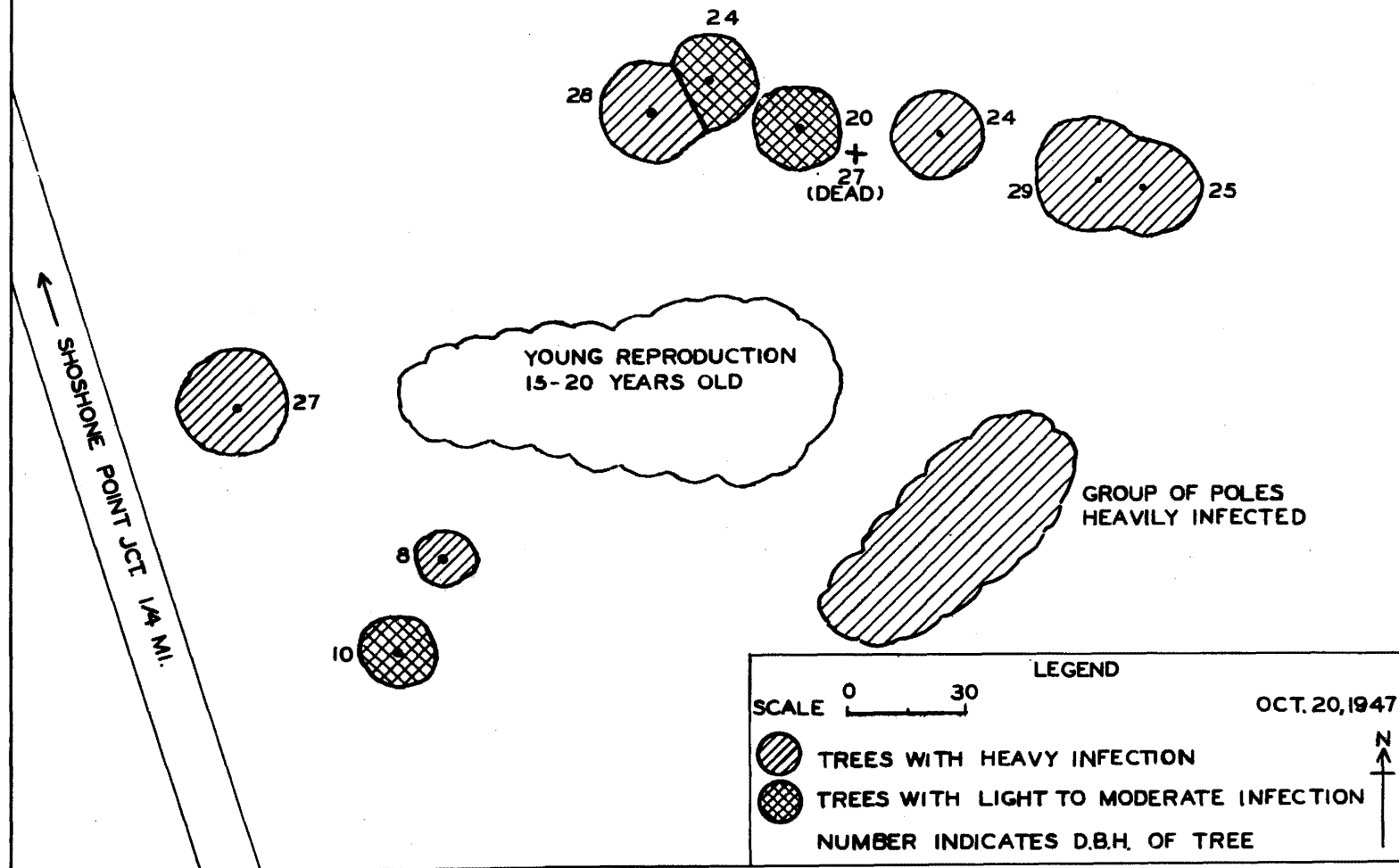


Figure 17.

Probably the first point to be considered with respect to control is whether or not the ponderosa pine, near the Rim at least, is worth preserving for future generations. If it is then preparations should first be made for mistletoe control east of Yaki point.

It is felt that no action would be advisable without first preparing a long-time plan showing the areas to be treated, and the objectives of each treatment. Since mistletoe control is expensive and since provision must be made for subsequent inspections and treatments after the first operation, no action is recommended until it is reasonably certain that it can be carried to completion.

It is felt that a plan designed to utilize permanent Park personnel during slack winter periods would be more effective than one calling for relatively large immediate expenditures.

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