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FOREST DISEASE SURVEYS.

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CONTENTS.

INTRODUCTION.

The National Forests are administered with the expectation of their becoming self-supporting through the medium of returns from such activities as timber sales, grazing, and special-use privileges. Of these operations, that of the sale of timber is, in the National Forests of the northwestern United States, unquestionably of the greatest importance in respect to paying the expense of administering the forest. In district No. 1 in the year 1916 the total receipts from timber sales equaled $439,880 and grazing $50,836. These figures show the relation between the two incomes derived from the principal forest activities of this district. Some few of the forests have already attained a position of self-support. One forest in particular is reported to have outdone all expectations and in so doing has aided in the administration of forests whose incomes have been less than their expenses. In such self-supporting forests it is always found that a ready market and available timber supply have resulted in a maximum of timber sales. It is, then, a foregone conclusion that timber sales in the National Forests of the Northwest are the mainstay of a self-supporting policy and that all data of value to timber-sale operations are bound to be of value in their successful supervision. The data and recommendations included in this paper are based on conditions prevalent in district No. 1 of the United States Forest Service.

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OBJECT OF FOREST DISEASE SURVEYS.

Timber surveys have as their prime object the gathering of such data upon proposed sales areas as will be of use in the appraisal and administration of the sales, and it is this survey which makes the sale possible. The collection of valuable data on the board-feet con-

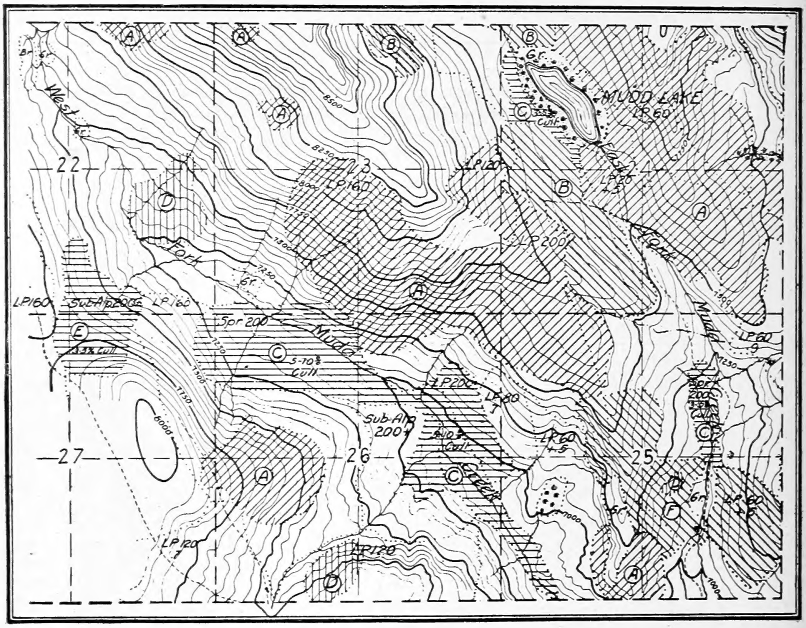

Fig. 1.—Pathological map of sections 22, 23, 24, 25, 26, and 27, T. 2 N., R. 15 W., the Big Hole area, based upon the map of the timber survey of that area in the Deerlodge National Forest, Mont., showing timbered areas infected with disease. The rot percentages are indicated for heart-rot (*Trametes pini* (Brot.) Fr.) and butt-rot (*Polyporus schweinitzii* Fr.) only. Crosshatching indicates infection areas. Other symbols on the map are part of the Forest Service map legend, such as Spr. 200, which indicates Engelmann spruce, 200-year age class; L. P. 60, 0.7 equals lodgepole pine 60-year age class, density 0.7; Gr. equals grassland; Br. equals brush. *A,* Pine rust (*Cronartium coleosporioides* (D. and H.) Arthur), gall and blister forms, on lodgepole pine (*Pinus contorta*); *B,* smelter-smoke injury, principally of alpine fir (*Abies lasiocarpa*) and Douglas fir (*Pseudotsuga taxifolia*); *C,* honeycomb rot (*Trametes pini* (Brot.) Fr.), principally on Engelmann spruce (*Picea engelmanni*); *D,* porcupine injury—peeling of bark and girdling of lodgepole pine; *E,* cubical butt-rot (*Polyporus schweinitzii* Fr.) on lodgepole pine and white-bark pine (*Pinus albicaulis*); *F,* mistletoe (*Razoumofskya americana* (Nutt.) Kuntze) on lodgepole pine.

tents of the stand, cull percentages, forest types, age classes, topography, and logging factors is followed by an accurate map portraying the topography, types, density, age classes, and timber estimates. A careful stumpage appraisal of the area based upon these available data and upon the various economic and topographic factors forms the final step before contracts are let.

In most cases the appraisal of a timber-sale area is based somewhat low in respect to the total feet board measure of sound material, principally on account of the unknown amount of defect or rot to be encountered and sometimes partially for other causes, foremost of which is the desire to prevent overestimation.

In timber surveys the estimating of timber is performed by members of the party who have been trained to estimate stands of varying mixtures, age, and soundness and who are thoroughly capable of

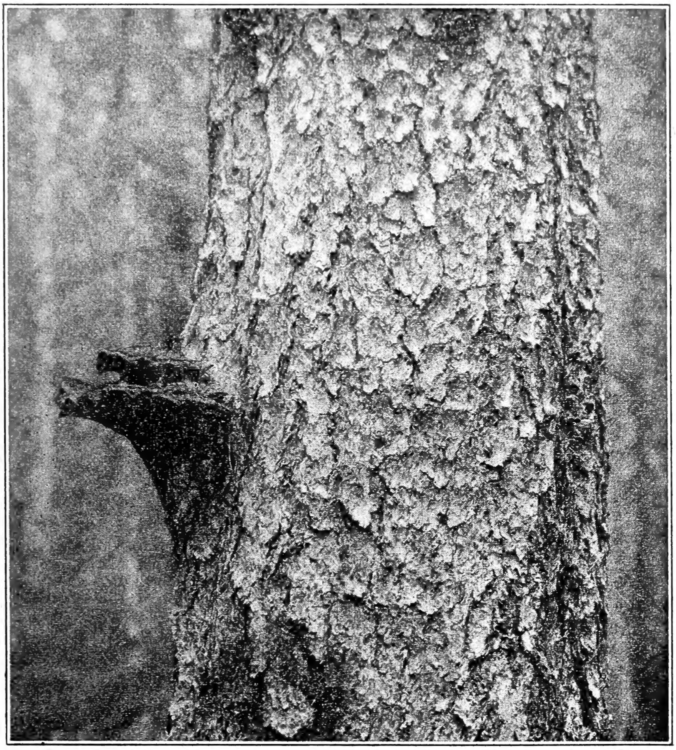

FIG. 2.—Fruiting bodies of *Trametes pini* on lodgepole pine. Notice the swelling of the trunk where the fruiting bodies are attached. (Photographed by G. G. Hedgcock.)

judging the board-feet contents of trees within reasonable limits of error. The addition to the party of an expert cruiser has been made as a means of aiding the estimators in this work and checking their results. The determination of the correct cull percentage due to rot is the aim of this arrangement in the crew.

In certain types and ages of stand the estimate may come close to the true scale, but, again, too small a percentage is deducted for cull due to rot, and consequently the estimate runs too high. A sale contractor figuring possibly on a conservative margin and accepting the estimate at its face value may find upon cutting the stand that a great deal more rot is encountered than was expected. This fact alone could easily result in the logging operation turning out a loss instead of a profit, especially if the logging chance is not a favorable one. Such failures doubtless do not encourage the undertaking of further contracts, and fewer timber sales are the result. This has its ultimate effect upon the forest as a whole in an economic way.

Recent studies made of the rots occurring[1] in forest trees have given information concerning the amount of decay prevalent in different age classes and in different sites for a particular species of tree. These studies have indicated that the decay in a tree or a stand varies with such factors as age of stand, site, density, injuries, and moisture relations. Such being the case, a disease survey of the sales areas made either as a separate pathological survey or in conjunction with the usual timber surveys would prove of immense value in a closer estimate of the sound board-feet contents of the stands. A disease survey in conjunction with the timber-survey work would no doubt be the more feasible plan of the two, since it would require no additional men for the crews and should not appreciably affect the cost per acre. All that would be required in order to secure the disease data in more accurate form is the training of one of the members of each unit crew in the proper methods by which the various pathological determinations are made. This would mean the ability to judge more accurately the cull percentage due to rot and the ability to recognize all the outward indications of decay as well as the principal fungi attacking forest trees. Preferably, the estimator should be the one selected to assume this duty, as it is his individual work which determines the total estimate and the cull percentage of the stand.

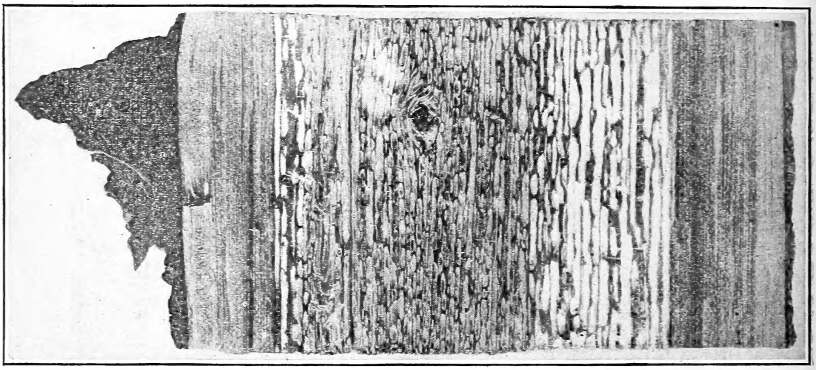

FIG. 3.—Typical rot of *Trametes pini* (honeycomb rot) in white pine.

[1] Meinecke, E. P. Forest pathology in forest regulation. U. S. Dept. Agr. Bul. 275, 62 p. 1916.

The topographer, while sketching in the type lines and indicating the age class divisions, can at the same time indicate the boundaries

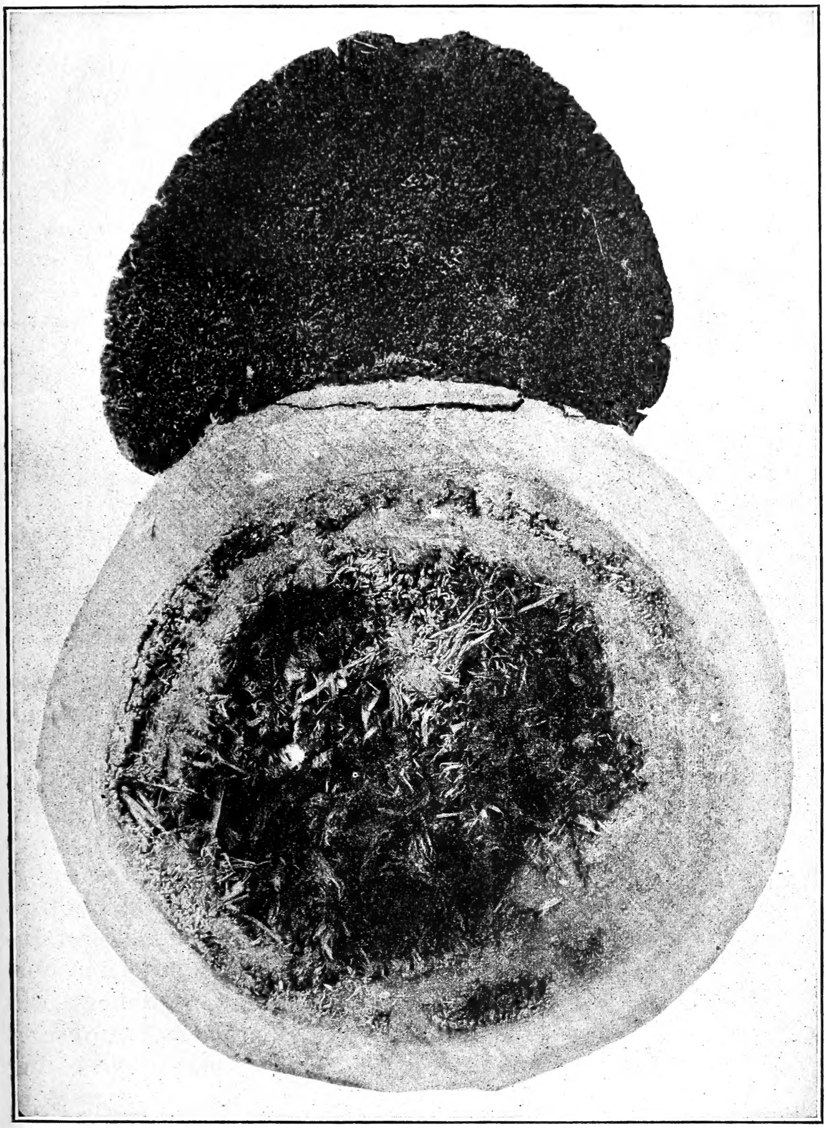

FIG. 4.—Typical rot of the Indian-paint fungus on *Abies grandis*. Note the spines on the fruiting body of the fungus. (Photographed by G. G. Hedgcock.)

of the heavier disease infections and also pencil in the cull percentages. In this way a pathological map[1] can be secured for the area

[1] Weir, J. R. Some suggestions on the control of mistletoe in the National Forests of the Northwest. *In* Forestry Quart., v. 14, no. 4, p. 567–577. 1916.

surveyed, and along with careful notes of the estimator upon the diseased areas and upon data secured by means of a few small sample

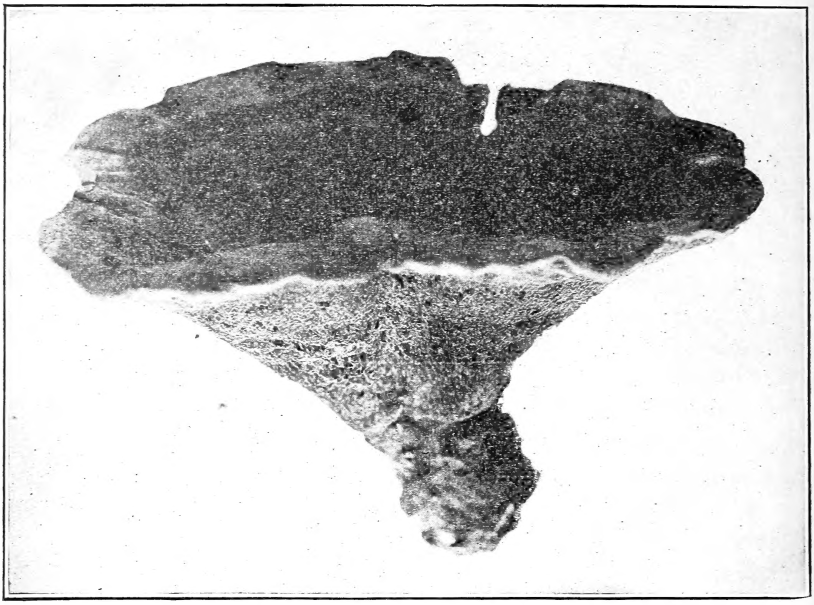

FIG. 5.—*Polyporus schweinitzii,* the velvet-top fungus.

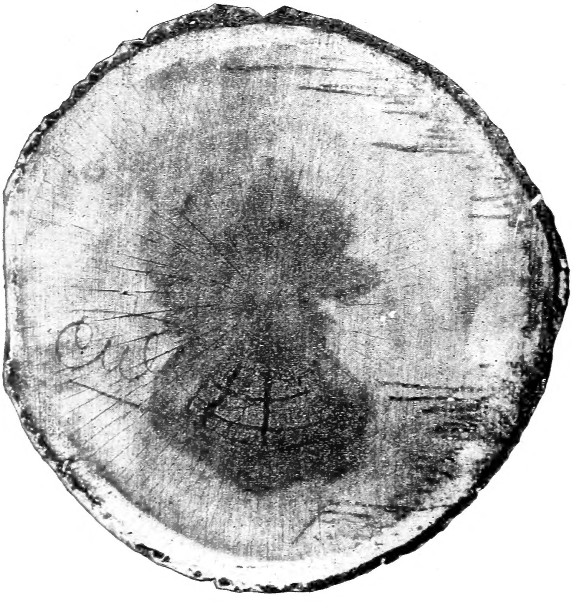

FIG. 6.—Typical rot of the velvet-top fungus in the end of a white-pine log. Note the cubical character of the rot.

plats a very close estimate of the cull percentage to be expected can be had. Checks can be made upon the estimator's work by the expert cruiser. Members of the Office of Investigations in Forest Pathology can render excellent service by aiding each unit crew in the field in becoming familiar with the various diseases and their causes.

If properly adjusted, this work would cause no variations in the amount of line run per day by the unit crews. The junior writer has tested and proved this assertion in practice while employed by the Forest Service on the Big Hole timber survey made in 1914 in the Deerlodge National Forest of Montana. From the data thus collected pathological maps were made, giving in colors the areas of the stand infected, respectively, with the pine rust (*Cronartium coleosporioides* (D. and H.) Arthur), both gall and blister forms, mistletoe (*Razoumofskya americana* (Nutt.) Kuntze), heart-rots (*Trametes pini* (Brot.) Fr. and *Polyporus schweinitzii* Fr.), and various other diseases (fig. 1). Careful notes

FIG. 7.—*Fomes pinicola,* the red-belt Fomes growing on grand fir.

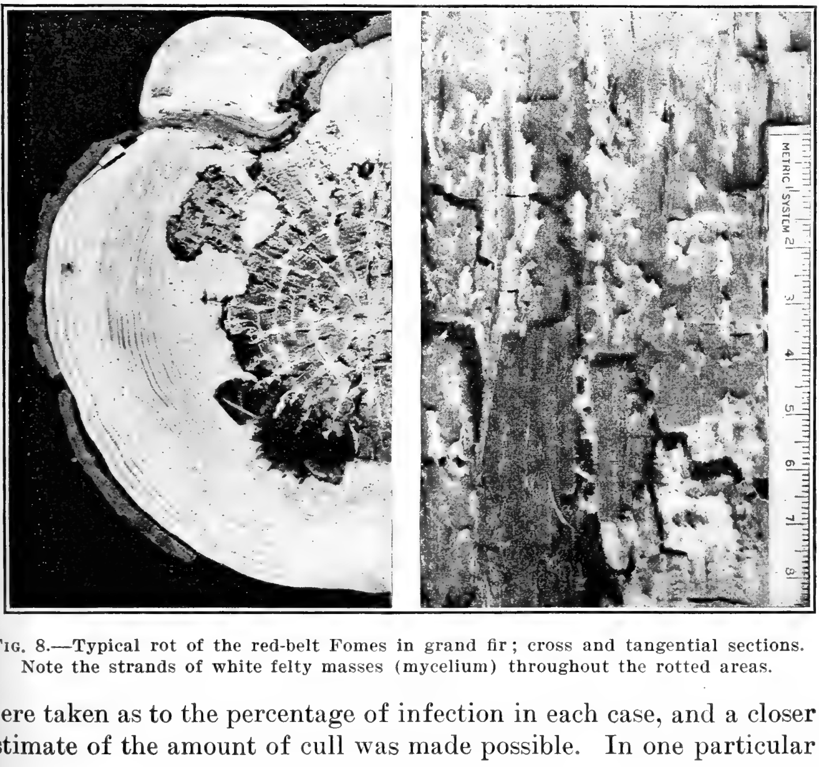

FIG. 8.—Typical rot of the red-belt Fomes in grand fir; cross and tangential sections. Note the strands of white felty masses (mycelium) throughout the rotted areas.

were taken as to the percentage of infection in each case, and a closer estimate of the amount of cull was made possible. In one particular case an estimator wished to give a full estimate of a stand of white-bark pine (*Pinus albicaulis* Engelm.) growing upon a flat ridge. The trees of this stand upon closer examination were found to be almost universally heart-rotted with *Polyporus schweinitzii* for a distance of 5 to 12 feet up from the base. The trees were fairly large and if sound would have made excellent stull material, the chief product in the Big Hole Basin region of Montana. Giving a full estimate to these trees would have meant a serious overestimation of the stand, since it was finally estimated that about 40 to 50 per cent by volume was cull due to the heart-rot. Fruiting bodies of the causal fungus almost hidden in the débris at the base of the trees gave the determining clue, and soundings upon the trunk followed by notching completed the determination.

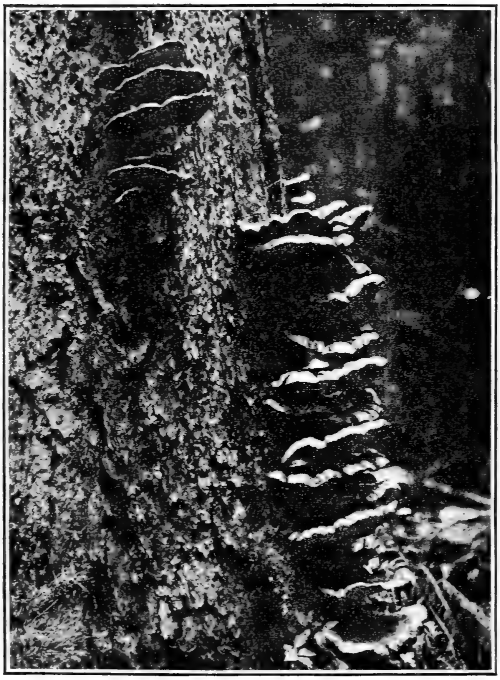

FIG. 9.—*Polyporus sulphureus*, sulphur fungus, at base of larch.

There has always been a serious need for some method by which a fairly accurate estimate can be made of the rate of decay of a stand of timber.

Good results as to the probable cull percentage to be expected from rot upon a certain stand have been secured by expert and experienced cruisers and appraisers. Timber surveys have in most cases placed the estimates of sound timber within a reasonable limit of error; but evidently no attempt has ever been made to secure a more accurate result in respect to the cull in a stand due to rot other than those results secured by ocular estimates. Occasionally in the administration of National Forests the question arises concerning the probable rate of increase in rot per annum in a certain stand of timber. The resultant decision as to the time of disposal of the timber hanging in the balance depends upon the amount of accurate knowledge and the data at hand regarding the decay in the trees. If proper and sufficient data are secured, these will furnish the total volume and the total volume of rot for the stand in question. With these as a basis and figuring in all the economic and silvicultural factors concerned, a cutting age can be computed, aimed to secure the greatest amount of sound material at a minimum of cost. No definite rule can be given as to the value of the ratio between the total volume and the volume of rot required in determining the cutting age. Too many factors are concerned even to generalize, and each stand must be judged according to the conditions present at the time it is under consideration. But it is unquestionably true that data giving the relation between the sound and the decay increment in a stand, as well as giving an approximation of the rate of increase in decay to be expected, will aid greatly in solving the question of the proper cutting age for that stand.

Forest management of this kind can be practiced to a profitable end provided intensive methods are employed in making a special disease survey of the area in question. Surely this would be a step toward more intensive and more economic forest management and would aid in solving many of the perplexing problems hinging upon the decay in timber. The cost of such a survey would not be prohibitive by any means, even in case the stand were composed of more than one age class, since sample plats of small dimensions could be successfully used in securing the necessary data upon the decay. To supplement these and aid in the diagnosis of the stand, such available data previously secured for similar tree species, age classes, sites, etc., could be used to advantage.

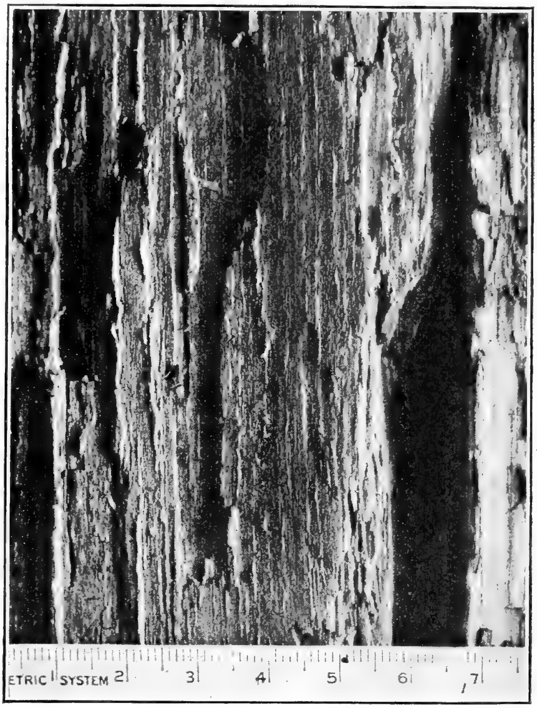

FIG. 10.—Typical rot of the sulphur fungus in larch.

Aside from the advantage secured in arriving at a more accurate rot percentage for a stand, a disease survey accompanied by a pathological map would be extremely useful after the sales are closed, the brush burned, and preparations made for the reforestation of the cut-over area. Looking into the future is the forester's basic principle, and whenever forestation of an area either by natural or artificial reproduction is contemplated it would be extremely unwise to overlook the risks to the young growth incurred by possible disease. A pathological map would serve to give the previous location of diseased trees, as well as the location of diseased uncut areas surrounding the sale area and the localities and sites where diseases seem most prevalent, and would also serve to indicate whether the seed trees left, if any, were of a group which was heavily diseased or not. Diseased trees of any kind left as seed trees or otherwise on or surrounding a cut-over area always act as distributing points of disease to the young growth occupying the near-by areas. For this reason attention has recently been centered upon the introduction and strict enforcement of sanitation clauses in all timber-sale operations.[1] These clauses include the removal by burning of all heavily infected standing trees and all cull material left on the area and strongly advise the use of healthy trees as seed trees instead of diseased ones.

Fig. 11.—*Fomes officinalis*, chalk fungus, on western larch.

For the same reason as given above for the protection of young growth in cut-over areas, a disease survey is even more necessary upon proposed nursery sites, present nursery sites, and all plantation sites. Wherever young trees are grown in close proximity to heavily diseased native trees or alternate hosts of forest-tree rusts there

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[1] Meinecke, E. P. Forest-tree diseases common in California and Nevada. U. S. Forest Service Manual, p. 62. Washington, D. C. 1914.

Weir, J. R. Some factors governing the trend and practice of forest sanitation. *In* Forestry Quart., v. 13, no. 4, p. 489. 1915.

Meinecke, E. P. Forest pathology in forest regulation. U. S. Dept. Agr. Bul. 275, 62 p. 1916.

Weir, J. R. Larch mistletoe: Some economic considerations of its injurious effects. U. S. Dept. Agr. Bul. 317, p. 24. 1916.

Weir, J. R. Mistletoe injury to conifers in the Northwest. U. S. Dept. Agr. Bul. 360, p. 33–37. 1916.

always remains a great danger of infection spreading to the young stock, with consequent loss. This has been shown in several recent cases where forest nurseries were located in close proximity to diseased trees and alternate hosts. At the forest nursery at Haugan,

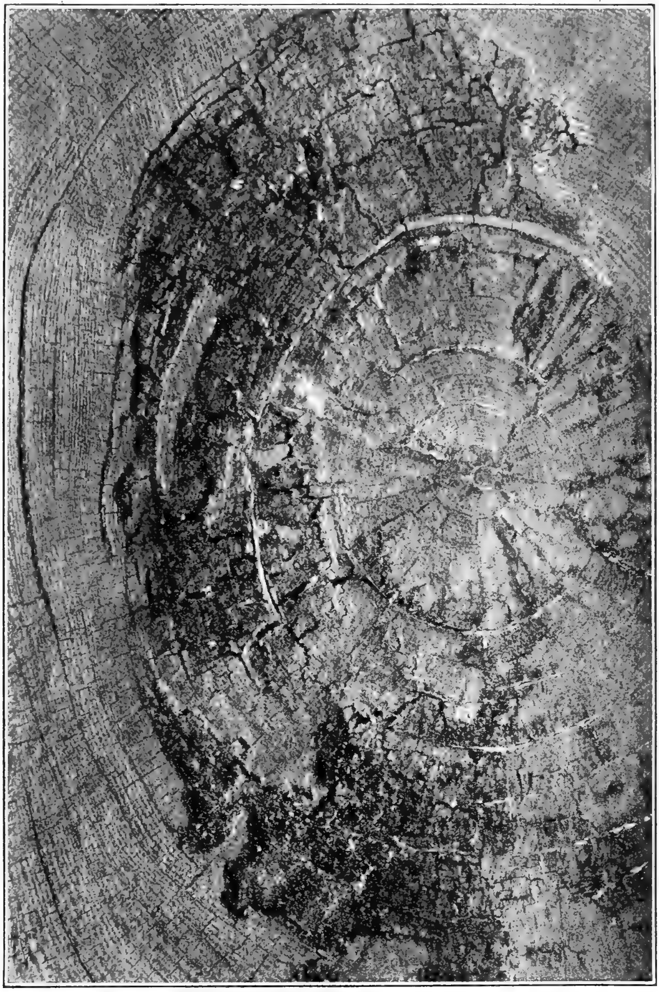

FIG. 12.—*Fomes officinalis*, chalk fungus, showing typical rot in lodgepole pine. Note the white mycelium in the cracks. (Photographed by G. G. Hedgcock.)

Mont., yellow-pine seedlings became seriously infected with *Cronartium coleosporioides* (*Peridermium filamentosum* Pk.). The disease was transmitted by means of the alternate form of the rust occurring on the Indian paintbrush (*Castilleja miniata* Dougl.), which was found growing at the very edge of the nursery beds.[1] A survey of

[1] Weir, J. R., and Hubert, E. E. A serious disease in forest nurseries caused by Peridermium filamentosum. *In* Jour. Agr. Research, v. 5, no. 17, p. 781–785. 1916.

the site, made at the time the nursery was contemplated, would no doubt have resulted in the discovery of the same rust upon the near-by lodgepole pines as well as upon the Indian paintbrush plants, and future losses would have been prevented. The infection with a needle fungus[1] of Douglas fir seedings at the Boulder nursery, Boulder, Mont., and the occurrence of a mistletoe upon the seedlings[2] were due to these diseases being extremely prevalent upon the surrounding native trees of this species. The young and crowded seedlings became ready hosts for the fungus, and considerable damage resulted.

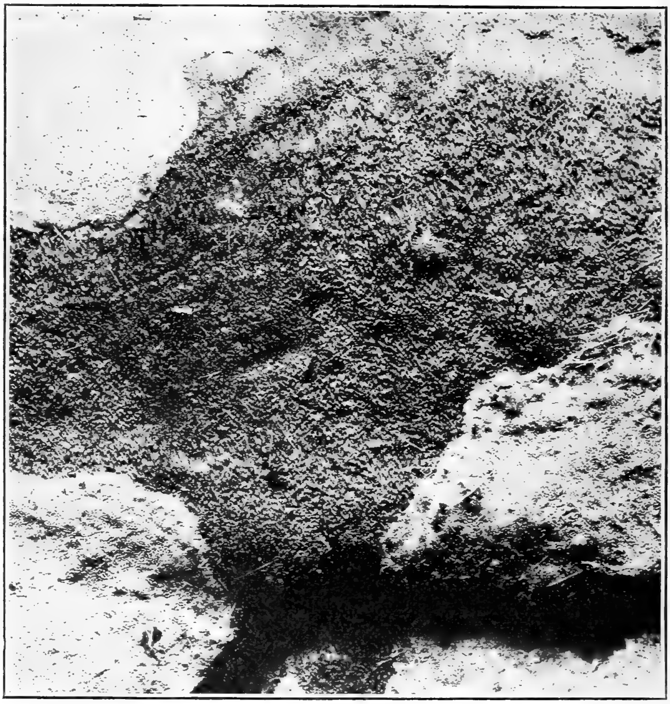

FIG. 13.—*Poria weirii,* brown-cedar poria. Fruiting surface.

In the State nursery at Roscommon, Mich.,[3] a similar proximity of native infected trees and susceptible nursery stock resulted in a serious epidemic.

No less care should be taken with proposed plantation sites upon burned-over or cut-over areas. A disease survey should be made

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[1] Weir, J. R. A needle blight of the Douglas fir. *In* Jour. Agr. Research, v. 10, no. 2, p. 99–103, 3 figs. 1917.

[2] Weir, J. R. Mistletoe injury to conifers in the Northwest. U. S. Dept. Agr. Bul. 360, p. 35. 1916.

[3] Kauffman, C. H., and Mains, E. B. An epidemic of Cronartium comptoniae at the Roscommon State Nurseries. In 17th Ann. Rpt. Mich. Acad. Sci., 1915, p. 188–189. 1916.

upon all such areas in which the newly transplanted seedlings are subject to infection by fungi or mistletoe. Many of the plantation sites of this region are located upon burned-over areas, and the majority of these are so badly fire swept that very little has been left in the form of coniferous hosts for forest-tree diseases. However, to review the succession of plant life on a burned-over area, after a fire which has been sufficiently intense to destroy every vestige of humus and litter, is to find that the alternative hosts of some viru-

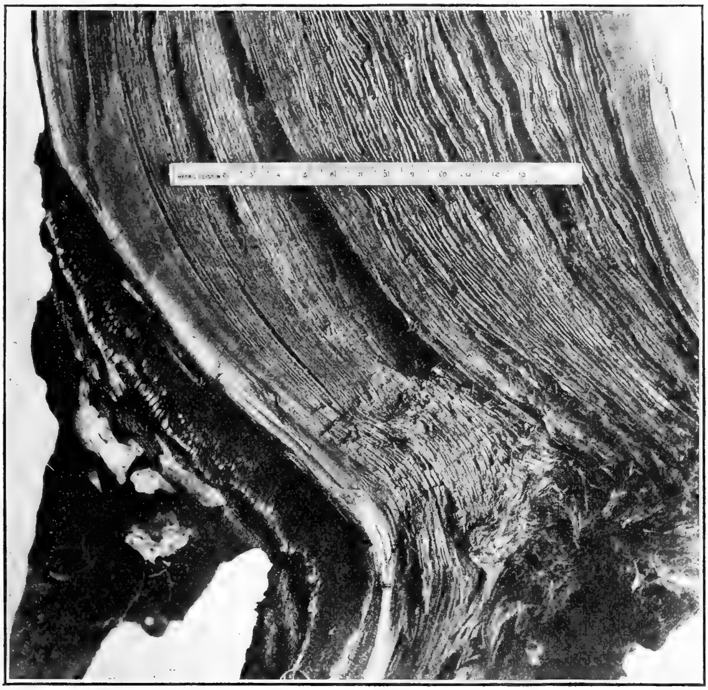

FIG. 14.—Typical rot of brown-cedar poria in butt and roots of cedar. Note the laminations of the rot and (on the left) the fruiting of the fungus.

lent needle or twig diseases have invariably appeared. In many cases the new plant succession carries with it alternate host plants of important forest-tree rusts which soon bear their parasitic fungi, and some of these are found to menace the young tree growth upon the area. A disease survey of such a site is very necessary, especially if the site is to be used as a plantation area for susceptible seedlings.

DISEASE-SURVEY METHODS.

The most practicable methods only are to be applied by unit crews in gathering forest-disease data. These methods should be applied with a reasonable knowledge of the principal destructive disease agencies, such as fungi, mistletoes, smoke, frost, wind, and snow injury, their outward recognition, and their possible and actual damage to the trees. Sample plats of small dimensions can often be resorted to in order to ascertain the extent of a heart-rot in a certain age class. Borings can be made with an increment borer on a few sample trees and thus the kind of rot and in the case of butt rots the extent of decay can be determined. Soundings on the trunk, the presence of sporophores, the number of dead branches or in-

FIG. 15.—*Fomes annosus*, root Fomes. Typical fruiting bodies.

juries, and the presence of the unmistakable swells and pitch flows occurring at old branch whorls all aid in the determination of the presence and extent of decay within a tree. The amount of decay bears a certain relation to the age of a stand, becoming greater as the stand grows older.

Owing to this fact, a table similar to the cull table given on page 25 of the Reconnaissance Manual of District 1, United States Forest Service, but giving the rot percentage only for a range of age classes for each tree species would prove of value in judging the decay in the stand. Such a table would give a range in rot percentages to be found in a certain age class, a certain site (slope and bottom) for a given tree species for a given kind of rot, and would be compiled from intensive field studies made upon felled trees. It would properly be termed a "table of rot percentages" and would be used by the estimator of each unit crew to determine the rot percentages for each type of forest encountered. Further deductions for other defects could then be estimated and the total cull percentage secured by the addition of the rot percentage. In conjunction therewith, another table giving (1) the class of defect, (2) common name of the defect, (3) the fungus causing it, (4) the various tree species affected, (5) the general external and internal characteristics of the defects, and (6) the average extent of the rots and the general form of the rot within the tree would be of great service to the estimator. Such a table prepared from field data secured during the past three seasons is here submitted. (Table I; figs. 2 to 23.)

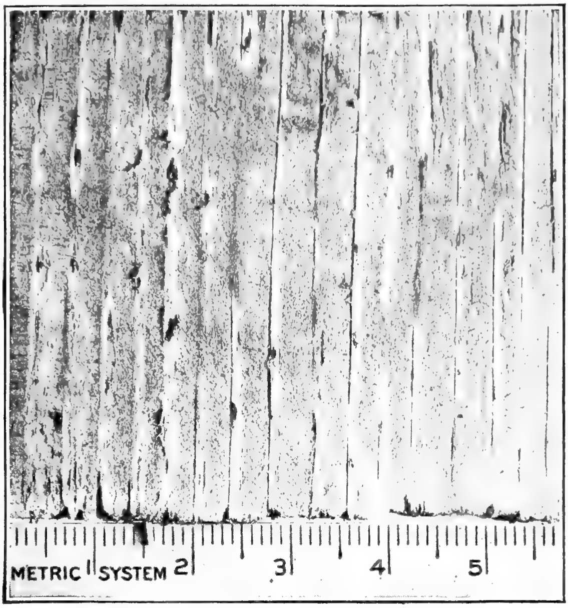

FIG. 16.—Typical rot of the root Fomes in grand fir. Note the black dots in the white areas.

FIG. 17.—*Pholiota adiposa,* the scaly Pholiota. (After Freeman.)

TABLE I.—*Decay determinations for standing trees for the use of estimators and marking officers.*

[Abbreviations: AF=alpine fir, C=western red cedar, DF=Douglas fir, ES=Engelmann spruce, GF=grand fir, L=western larch, LP=limber pine, LPP=lodgepole pine, MH=mountain hemlock, WBP=white-bark pine, WH=western hemlock, WP=western white pine, YP=western yellow pine.]

Class of defect.	Common name for the defect.	Causal parasite (scientific and common names).	Trees generally attacked.	External signs of decay or defect.	Characteristics of decay.
Trunk-rot, occasionally acting as butt-rot; generally patchy.	Honeycomb rot. (fig. 3).	Trametes pini, ring-scale fungus (fig. 2).	WP, YP, LPP, WBP, LP, ES, WH, MH, AF, GF, C, DF, and L.	Typical fruiting bodies of the fungus on the tree; indications at old branch whorls, either by swells or by brownish punky substance, that fruiting bodies have dropped off; soundings made on the trunk to detect hollowness or punkiness, indicating decay; many injuries of various kinds; presence of typical rot; catfaces at the base induce the butt-rot form.	Heart-rot in resinous trees; heart-rot or sap-rot in trees of little or no resin; in early stages, reddish color in split section, with small or large white elliptical patches, punky, soft, brown (discolored); in cross section, small white patches mingled with pitted areas and in advanced stages ring scaled, annual rings separated; delignifying rot, viz, converting wood to cellulose; white-rot; conical in both directions from the area of greatest decay in trunk; as butt-rot, conical, tapering at upper limits; often as patchy areas not uniformly attacking the heartwood.
Trunk-rot (uniform, circular); entire tree.	Stringy brown-rot (fig. 4).	Echinodontium tinctorium, Indian-paint fungus (fig. 4).	AF, GF, WH, and MH.	Typical fruiting bodies of the fungus on the tree; indications at branch whorls, either by swellings or by deep rusty-red punk knots, that fruiting bodies have dropped off; large number of dead branch stubs, accompanied by pronounced swellings at whorls; deep rusty-red color in old branch stubs; soundings made on the trunk; many injuries, such as logging scars, fire scars, blazes, etc.; presence of typical rot.	Uniform heart-rot (confined to given tree species almost entirely); in early stages, wood spongy, yellow stained; typical stage, soft, stringy, brownish to rusty red in color, knots showing a deep rusty-red color; sawed surface (cross section), pitted, broken, and stringy, with reddish brown discolorations, often hollow rotted; carbonizing rot, viz, reducing cellulose, producing dark-colored decay; conical in both directions from the area of greatest decay; very uniform in occupying most or all of the heartwood.
Butt-rot, from roots up to 12 feet into first log (uniform, circular); usually 5 to 6 feet up.	Cubical butt-rot (fig. 6).	Polyporus schweinitzii, velvet-top fungus (fig. 5).	WP, YP, LPP, WBP, LP, DF, GF, AF, and C.	Typical fruiting bodies of the fungus on the ground near the tree (nearly always partly covered by débris), sometimes found as bracket fungus issuing from injuries at the base of the tree (never high up on the trunk); indications of brown-rot in the exposed roots; soundings on the basal portion of the tree and on exposed roots; presence of typical rot.	Uniform heart-rot of butt of tree (also enters roots): in early stages, light reddish brown; typical stage, reddish brown; pronouncedly cubical, crumbly, and brittle when dry; occasionally with thin resinous crusts of white feltlike material (mycelium); odor of turpentine; carbonizing rot; conical from the base of the tree upward; uniform, usually not advancing beyond first log.

Trunk-rot (uniform, circular).	Brown crumbly rot, (fig. 8).	Fomes pinicola, red-belt fungus (fig. 7).	All the important conifers, principally L, WH, MH, AF, and GF.	Typical fruiting bodies of the fungus on the tree; typical rot at old branch stubs; soundings made on the trunk; presence of typical rot.	(1)
Do.	Reddish brown heart-rot (fig. 10).	Polyporus sulphureus, sulphur fungus (fig. 9).	Almost all important conifers, principally L, DF, YP, ES, and WP.	Typical fruiting bodies of the fungus on the tree; soundings made on the trunk; presence of typical rot.	Uniform heart-rot; in early stages, light brown, typical stage, dark reddish brown; brittle when dry, crumbly (not pronouncedly cubical), with thick felty mycelial masses in clefts, star shaped in cross section; carbonizing rot; conical, uniform.
Trunk-rot (entire tree); in YP occupies upper part of the tree.	Reddish brown heart-rot (fig. 12).	Fomes officinalis, chalk fungus (fig. 11).	All important conifers, principally L, YP, DF, and ES.	Typical fruiting bodies of the fungus on the tree (the principal means of distinction between rots of this species and that of the sulphur fungus); soundings made on the trunk; presence of typical rot.	Uniform heart-rot; in early stages, light brown; typical stage, dark reddish brown, brittle, dry, crumbly, with thin felty mycelial masses in clefts; carbonizing rot; conical, uniform.
Butt-rot; from roots up to 8 feet into butt log.	Yellow laminated rot (fig. 14).	Poria weirii, brown cedar poria (fig. 13).	C and eastern arbor vitæ.	Typical fruiting bodies of the fungus on the tree (in the root crotches often cementing the forest débris about the roots into a punky mass); soundings at the base of the tree and on exposed root spurs.	Uniform heart-rot; light-yellow color; decayed spring wood separating annual rings in advanced stages, brown felty myce; lium between layers; carbonizing rot; conical, uniform.
Butt-rot (uniform, circular); from roots up to 8 feet into butt log.	White spongy rot (fig. 16).	Fomes annosus, root Fomes (fig. 15).	ES, WP, YP, LPP, WBP, LP, WH, MH, AF, GF, C, DF, and L.	Typical fruiting bodies of the fungus in the root crotches, usually covered up; resin flow at the base of the tree or roots; soundings at the base of the tree and on exposed roots.	(2)
Trunk-rot (uniform, circular).	Yellow heart-rot (fig. 18).	Pholiota adiposa, scaly pholiota (fig. 17).	GF, AF, WH, MH, ES, and WP.	Typical fruiting bodies of the fungus on the tree; soundings made on trunk; presence of typical rot.	(3)
Burl injury.	Mistletoe burls (fig. 20).	Razoumofskya spp., mistletoe (fig. 19).	YP, LPP, WH, MH, L, and DF.	Typical mistletoe plants upon branches and twigs; witches'-brooms; conspicuous swellings on the trunk or branches.	
Galls and cankers.	Pine cankers (fig. 23).	Cronartium coleosporioides, gall and blister forms; Cronartium comandrae, pine rust (figs. 21 and 22).	YP and LPP.	Presence (during months of May to August) of orange-yellow, powdery masses on pronounced swellings; catfaces or cankers of trunk and branches, absence of mistletoe plant upon galls and cankers.	When fruiting stage is inconspicuous during May to August, a light chipping of bark on swellings and cankers will disclose orange-yellow powder or fruiting layer.

[1] Uniform heart-rot, found principally in dead standing and down timber; occasionally acting as heart-rot in living trees by gaining entrance through injuries; in early stages, rot light brown; typical stage, reddish brown, cubical, crumbly and brittle when dry, white feltlike layers of mycelium between cubical patches; felt patches larger, thicker and nonresinous as compared to those of the velvet-top fungus; carbonizing rot; conical, uniform.

[2] Uniform sap-rot and heart-rot of butt: in early stages, ranging from lilac to reddish in color; typical stage, whitish areas separated by smaller areas of sound wood (not prominently pitted), occasionally with black dots in center of white areas; in last stages, annual rings separated, finally spongy; fine felty masses (mycelium) under bark scales; delignifying rot; conical, uniform, filling heartwood and part or all of sapwood.

[3] Uniform heart-rot (principally of trees with little or no resin); in early stages, a light-yellow stain; typical stage, yellow or honey color, brownish streaks; yellowish to light tan or white felty masses running across the grain and breaking up in last stages and separating annual rings, finally becoming hollow rotted; carbonizing rot; conical in heartwood.

It is readily seen that Table I will aid greatly in determining the rot in the tree by means of external characters, and after the class of defect and the cause have been determined by its use it will be comparatively easy to select the proper rot column in the table of rot percentages for any one tree species. In this manner the two tables can be used conjunctively in securing a more accurate rot percentage for the stand.[1] Until it is possible to obtain accurate data from a large number of trees of all the species composing the prevalent forest types of this region, no table of rot percentages will be presented.

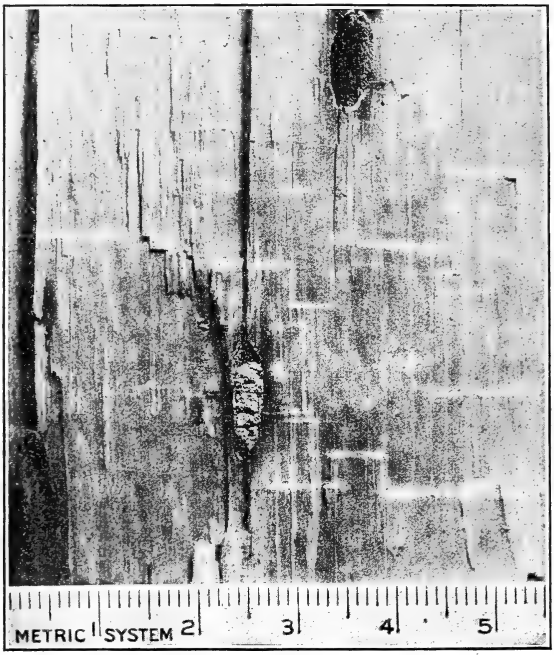

FIG. 18.—Typical rot of the scaly Pholiota in grand fir. Note the horizontal streaks formed by the yellowish felty mycelium.

Since the type lines are sketched on the topographic map on the basis of age class, it will be found advantageous to study and record the rot data upon such a basis. This will make it easier to produce pathological maps of the area by using white prints from the type-sheet tracings of the timber survey maps.

In a unit crew consisting of two men (an estimator and a topographer), the estimator can be trained to determine the cause of the disease and the amount and therefore the rot percentage, recording such data accurately for the strip which is being surveyed. Since the estimate sheets have blank spaces for the recording of all disease and other injuries suffered by the stand, as well as for the estimated loss in cull due to each, the only change that a more intensive disease survey will incur will be the additional work done by the topographer. He will be required to indicate upon his map the boundaries

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[1] Weir, J. R. Difficult problem of the control of fungus diseases in the forest. *In* Timberman, v. 14, no. 9, p. 27–29, illus. 1913.

Weir, J. R. Some problems in conservation with reference to forest hygiene. *In* Timberman, v. 14, no. 11, p. 28–31, illus. 1913.

Meinecke, E. P. Forest tree diseases common in California and Nevada. Washington, D. C. 1914. These publications may be found useful in the determination of various kinds of defects.

of the various infections and to show therein the estimated cull due to each. This information can easily be secured by coobservation with the estimator, who can supply the actual figures for the rot percentages and aid in determining the boundary lines of infection. This will produce sufficient reliable data upon which to base valuable pathological maps, which can be compiled either with colored areas to indicate the diseases and inclosed figures indicating the rot percentages or can be drawn in black and white, using lines dif-

FIG. 19.—*Razoumofskya campylopoda*, mistletoe, on yellow pine.

fering from type lines to indicate the boundaries of the infected areas and placing the rot percentages in figures within this area.

PATHOLOGICAL MAPS.

Maps indicating the distribution of diseases in forest areas have not been used to any great extent. In German literature, articles are to be found dealing with plant diseases which have such maps illustrating the distribution of the disease. Very few contain maps dealing with the distribution of forest-tree diseases and none at all dealing strictly with the distribution of fungous infection in forests.

In this country considerable use has been made of disease-distribution maps by the various workers along the line of plant and forest pathology. This is noticeable in the work done in the study of the chestnut-blight fungus[1] and in the study of two of our important forest-tree rusts.[2] These are all maps of the plain black-and-white type, showing by means of symbols the localities where infection was reported and thus indicating the distribution of the disease. The earliest colored maps used in forest-disease investigations are found in German literature and deal mainly with the distribution of zones of timber damaged by smelter fumes.

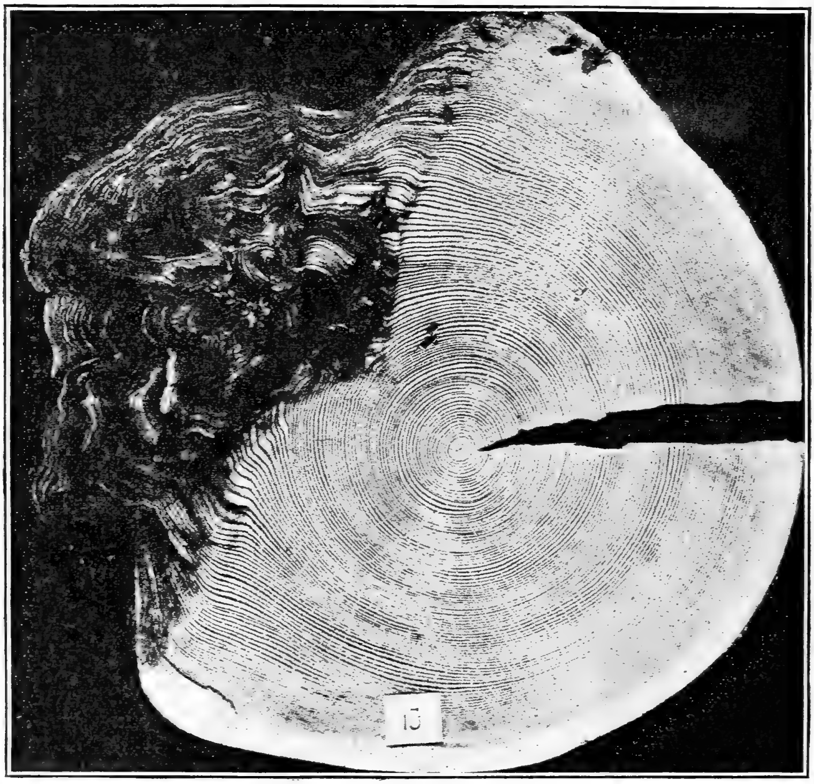

FIG. 20.—Mistletoe burl affecting one side of larch log. Size of burl, 3½ feet long by 13 inches in diameter. The cull equaled 25 feet board measure.

Colored maps giving the distribution of smelter-smoke damage were published in a book on smoke damage to vegetation by

[1] Rankin, W. H. Field studies on the Endothia canker of chestnut in New York State. Phytopathology, v. 4, no. 4, p. 237. 1914.

[2] Spaulding, Perley. The blister rust of white pine. U. S. Dept. Agr., Bur. Plant Indus. Bul. 206, 88 p., 2 pl. (1 colored). 1911. Bibliography, p. 61–78. Map showing distribution of blister rust in Europe, p. 14.

Hedgcock, G. G., and Long, W. H. A disease of pines caused by Cronartium pyriforme. U. S. Dept. Agr. Bul. 247, 20 p. 1915. Literature cited, p. 20. Map showing distribution of Cronartium pyriforme, p. 8.

Schroeder and Reuss in 1883.[1] Other works by Schroeder and Schertel in 1884[2] and Borggreve in 1893[3] also give maps in connection with studies of smoke, the latter maps being uncolored. No references were found which contained colored maps of the distribution of forest-tree diseases.

In the making of timber-survey maps, type boundaries are indicated by continuous dotted lines inclosing within the areas so formed the figures indicating type mixture, density, and age class, the age class also being separated by dotted lines. Very often these areas are colored by the use of wash inks or crayons, so as to make a greater distinction between them. A number of standard colors are used and are applied upon white prints, which are found to give the best results. A similar method is proposed for use in making pathological maps, the only variation being the addition to the type-sheet maps of boundary lines indicating the infected areas and a special set of colors indicating various diseases. In the pathological maps only those colors denoting the various infections should be used, leaving the type areas uncolored.

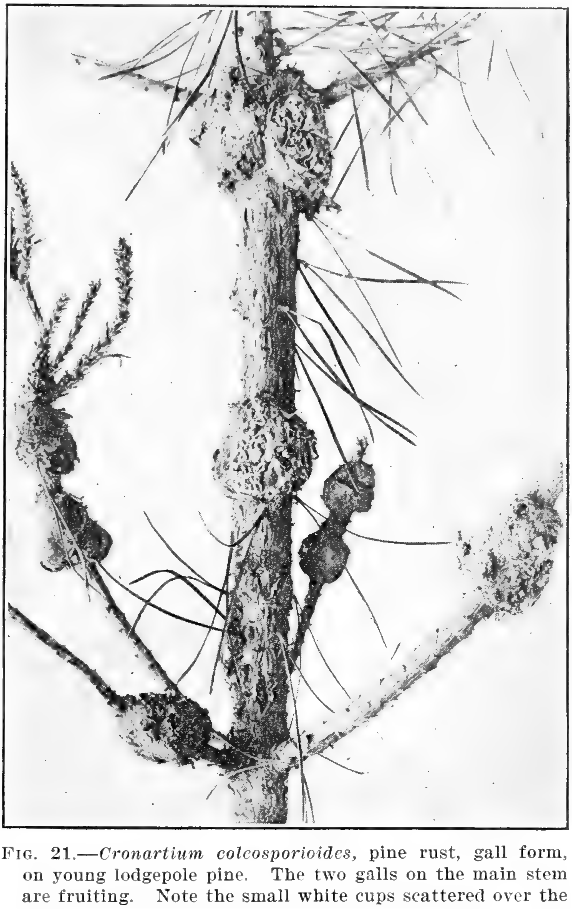

FIG. 21.—*Cronartium coleosporioides,* pine rust, gall form, on young lodgepole pine. The two galls on the main stem are fruiting. Note the small white cups scattered over the surface of these two galls.

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[1] Schroeder, Julius von, and Reuss, Carl. Die Beschädigung der Vegetation durch Rauch und die Oberharzer Hüttenrauchschäden. 333 p., 2 maps (colored). Berlin, 1883.

[2] Schroeder, Julius von, and Schertel, A. Die Rauchschäden in den Wäldern der umgebungder physikalischen Hüttenwerke bei Freiberg. Separat-Abdruck Jahrb. Berg. w. Hüttenw. Königr. Sachsen, 1884, p. 93–120, map (colored). 1884.

[3] Borggreve, B. Rauchbeschädigung in dem von Tiele Winkler'schen Forstreviere Myslowitz-Kattowitz. 236 p., 2 maps. 1893.

The maps will be found valuable not only as an interpretation of the data taken in intensive disease surveys in connection with timber surveys but in the appraisal, marking, and general administration of the sale area. With regard to appraisal the map will indicate the location of seriously infected areas and also the rot percentages. With respect to marking, the map will show the exact area of the

FIG. 22. — *Cronartium coleosporioides*, pine rust, blister form, on 2-year-old seedlings of yellow pine.

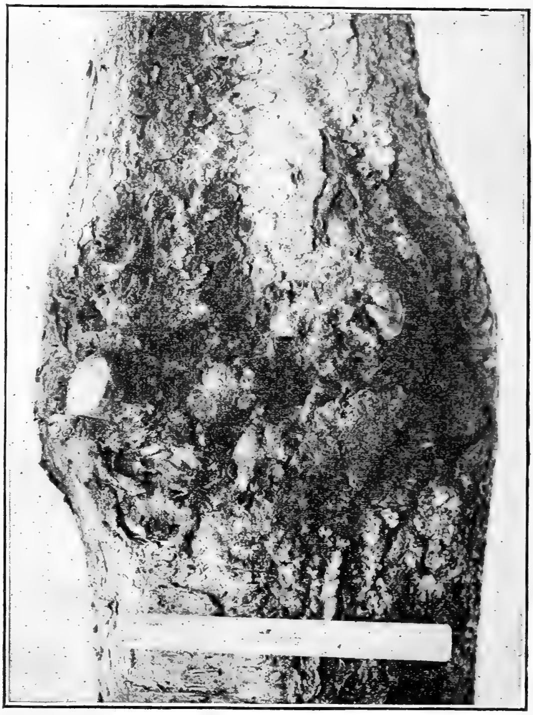

FIG. 23.—*Cronartium coleosporioides*, pine rust, blister form, an old infection, on the main trunk of lodgepole pine, known locally as "hip canker" or "catface."

most seriously infected trees and aid in the exclusion of infected trees for seed trees. From the standpoint of general administration, the maps will show the location of sites and age classes upon which heavier marking must be employed in order to conform with the most effective sanitation clauses.

With regard to reforestation by artificial or natural means, these maps will show the proximity of infected stands and whether or not the site has been or apparently is favorable to excessive disease.

SUMMARY.

Forest disease surveys when carried out in conjunction with timber-survey projects will furnish data of economic value in conducting future sales of the areas in question.

Pathological maps indicating the principal infection areas can be compiled from the data secured by these forest disease surveys.

These maps will be found of practical value in the appraisal, marking, and general administration of the sale area. They will prove of practical use in both artificial and natural reforestation and will also prove useful in indicating the general distribution of forest-tree diseases in our National Forests.

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