ECONOMIC GUIDES for blister-rust control in the East

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A Need for Guides

WHITE PINE blister rust *(Cronartium ribicola,* Fischer) is a virulent and potentially serious disease of eastern white pine *(Pinus strobus,* L.) Control of this introduced rust has been carried on since about 1910 in the eastern United States. Today, after more than 50 years of control effort, the occurrence of blister rust in this region is gratifyingly infrequent. Because of effective and continuing control programs, blister rust has been brought under control, and is not now a serious threat to pine management in most areas of the East. Yet, control must continue if blister rust is to remain under control in the future.

Several efforts have been made in years past to provide control personnel with guides and standards for determining the conditions under which control is a worthwhile undertaking. Better guides can enhance the economic effectiveness of control programs by aiding control personnel in recognizing good control opportunities, and in avoiding poor ones. These guides aid program administrators as well, because they are a necessary adjunct to determining the amount of control justified for a district, state, or region.

Evaluating Control Opportunities

The essential decision facing a blister-rust-control worker, as he examines a control area, is whether to undertake a control treatment now or to delay treatment at least until the next examination, say 10 years hence. He must decide whether the additional value saved by immediate treatment is great enough to warrant the cost of the treatment. If it is, then immediate treatment is indicated: if it is not, then postponement is the better course.

First-Order Conditions

There is no economic return to rust control unless: the protected pine will be harvested; the protected pine is more than 20 years from harvest; and ribes are present and there are signs of current pine infection.

These are three first-order conditions that must be met by all pine stands scheduled for treatment. Some pine stands will not be harvested when they mature because of inaccessibility or because they are on lands where harvest is prohibited. Protection in such cases must be justified on other grounds than those considered here. Pine stands within 20 years of harvest will not lose any appreciable amount of stocking from further rust infection because it takes nearly that long for rust to kill heavy poles and small sawtimber. And of course there is no point in considering immediate treatment where no ribes population occurs in or near the stand, or where there is no sign of current infection.

Required Information

If the three first-order conditions are met, control will result in some benefit. The next phase in evaluation is to determine whether this benefit is great enough to justify the cost of control. Eleven items of information about the control area are needed to use the evaluation procedure presented here:

1. *Observed infection rate.* The percentage of pine first infected with blister rust 6 to 10 years before examination.
2. *Climatic hazard.* Within the high climatic hazard zone, or the

low hazard zone (fig. 2).

3. *Pine density.* The average number of uninfected free-to-grow pines to be found on occupied plots 1/200 of an acre in size.
4. *Stand type.* Planted or natural.
5. *Ownership class.* Public or private.
6. *Site index.* Less than 60 feet in 50 years, between 60 and 80 feet, or more than 80 feet.
7. *Stand-age class.* The average age of the pines being protected, by 20-year classes 1-20 years, 21-40 years, 41-60 years, and so on.
8. *Years to harvest.* Assumed rotation age (table 1) less the midpoint of stand-age class.
9. *Weevil-control class.* Control has been or is being practiced, or not.
10. *Stocked pine area.* That part of the total pine area made up of occupied plots as defined in 3 above, in acres.
11. *Control cost.* The number of man-days of labor and supervision required to destroy ribes within the control area, multiplied by 26 dollars and divided by the stocked pine acreage.

Some of these items of information are readily available from maps and records, or are immediately evident from examination. Other items, particularly infection rates and pine density, are best established by measuring sample strips or plots distributed over the pine area.

Figure 1 summarizes the relationships that determine the value saved by immediate control. With the information specified above, this figure can be used to estimate the present worth of value saved per stocked acre. Value saved is compared with the control cost per stocked acre (item 11) to determine whether or not immediate control is justified. Figure 1 also gives three intermediate estimates that may be of interest: the rate of infection to be anticipated during the next decade, the proportion of stocked area that will be denuded during the next decade, and the loss in harvest volume this will entail.

An Example

The following section discusses these evaluation procedures and relationships in detail. But a brief example may be helpful at this point in providing an overall understanding of the mechanics of the evaluation process.

Consider a 560-acre control area on private land in northern New York, containing a 210-acre natural pine stand mostly in the

1-20 year age class. A survey of the area shows that about 3 percent of the pines were fatally infected with blister rust during the 5-year period beginning 10 years before examination. Since this control area is in the high hazard climatic zone, the upper right-hand graph in figure 1 indicates that there is likely to be about a 15-percent infection rate during the next decade.

The stocking in this pine stand is irregular, with some 20 percent of the pine area in openings of 1/200 acre or more, or stocked with species other than pine. On the average, there are two uninfected free-to-grow pines per 1/200 acre over the remaining 80 percent of the pine area actually occupied by pine. The upper left-hand graph in figure 1 indicates that, with an expected infection rate of 15 percent, and a present density of two pines per 1/200 acre in the occupied pine area, this natural stand is likely to lose about 7 percent of its stocked area during the next decade if control is postponed.

Measurements on a few older pines scattered over the pine area indicate that the 50-year site index for white pine is somewhere between 60 and 80 feet. The lower left-hand graph in figure 1 shows that a 7-percent loss in stocked area, on a private ownership of medium site quality, means that a little over 3,000 board feet of harvest volume will be lost per stocked acre if control is delayed.

Seventy years is the rotation age assumed in this analysis for

Table 1. — *Average net sawtimber yield at harvest for fully stocked stands of eastern white pine, by site index and ownership class*

50-year site-index class (*feet*)	Ownership	Rotation age assumed	Average net yield per acre of sawtimber for fully stocked stands, International 1/4" rule
		Years	*M board feet*
Less than 60	Private	80	25
	Public	100	35
60-80	Private	70	45
	Public	90	65
More than 80	Private	60	60
	Public	80	85

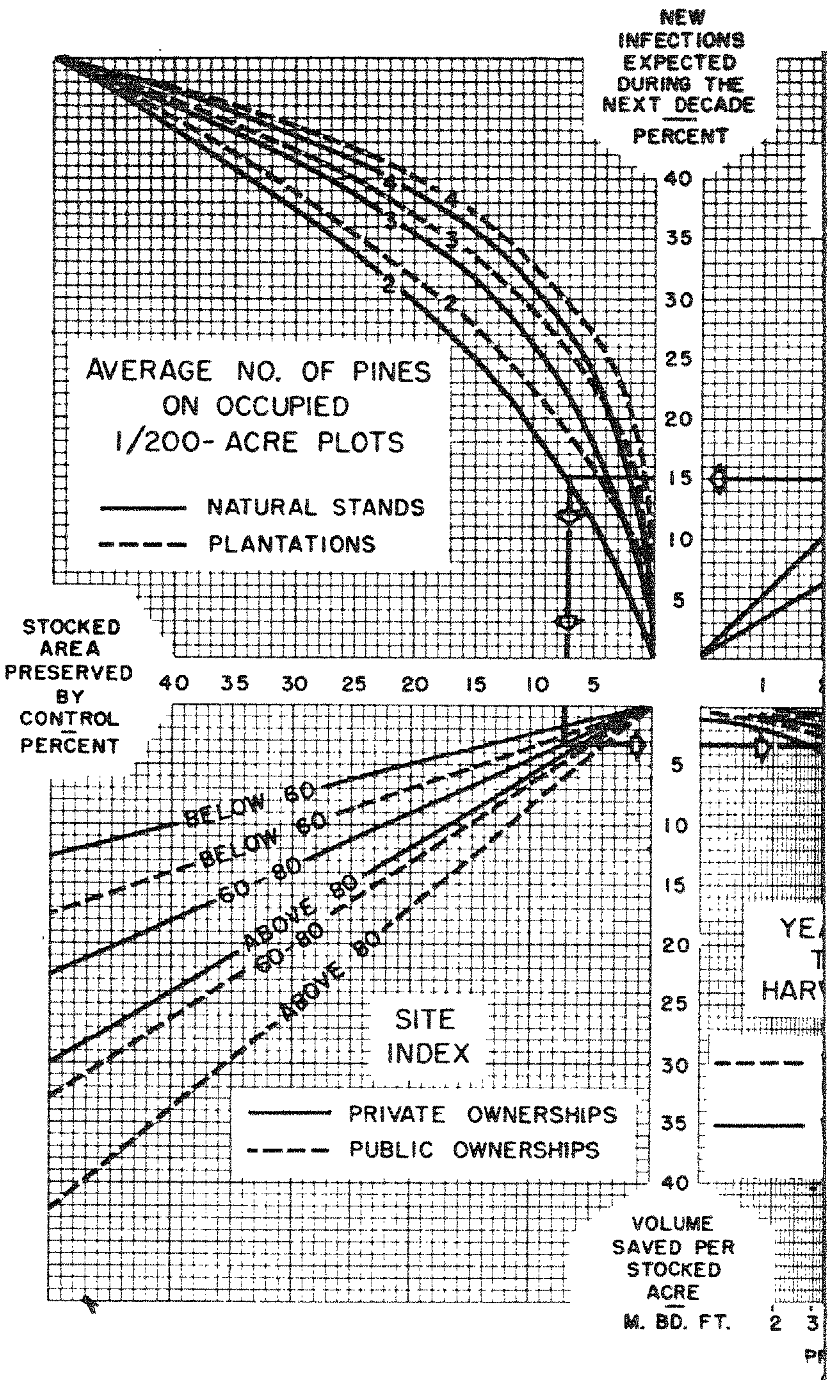
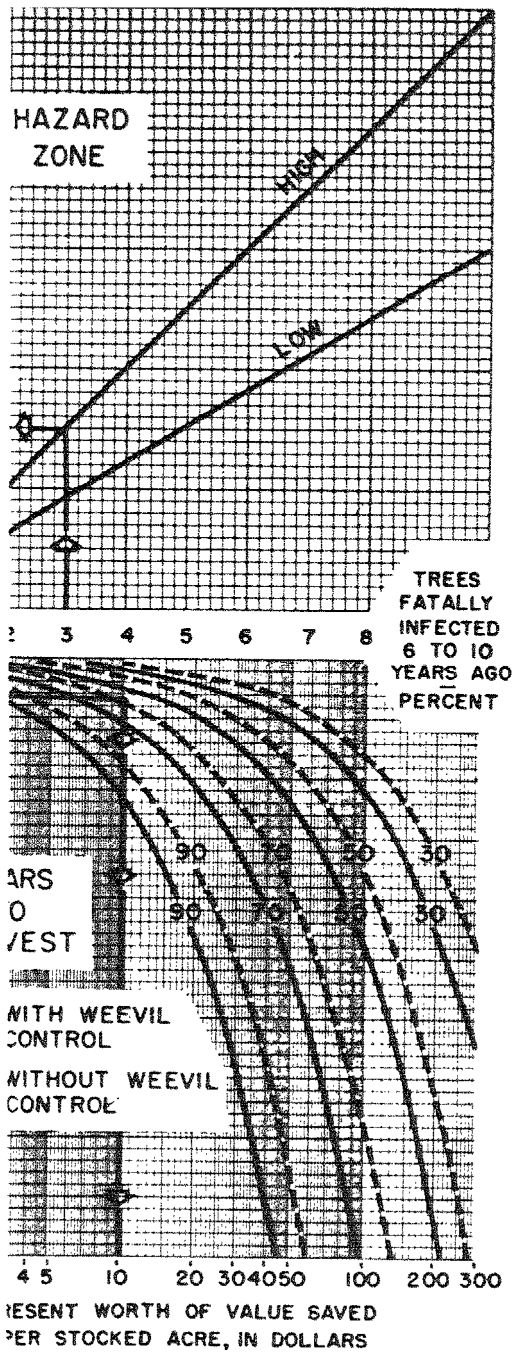


Figure 1.—The value saved by not delaying blister-rust control.



HAZARD
ZONE
HIGH
LOW
TREES
FATALLY
INFECTED
6 TO 10
YEARS AGO
PERCENT
2 3 4 5 6 7 8
90 70 50 30
90 70 50 30
ARS
O
VEST
WITH WEEVIL
CONTROL
WITHOUT WEEVIL
CONTROL
4 5 10 20 30 40 50 100 200 300
RESENT WORTH OF VALUE SAVED
PER STOCKED ACRE, IN DOLLARS

pine on private ownerships of medium site quality (table 1). Since the stand is now about 10 years old, about 60 years remain until harvest. Weevil control has not been undertaken in this pine area. The lower right-hand graph in figure 1 shows that under these circumstances the present worth of the harvest value that can be saved by control is about $10 per stocked acre. This value results from multiplying the volume saved by a unit value of $30 per thousand board feet, and discounting this harvest value for 60 years at 4 percent.

The final task is to compare this value saved with expected control cost. It will take a 3-man crew about 5 days to treat this control area thoroughly. This means about 15 man-days, at a unit cost of $26 on the basis of recent experience, or a total cost of $390 for the control area. Since there are 168 acres (0.8x210) actually stocked by pines in the pine area, this works out to a treatment cost of only a little over $2 per stocked acre. So in this example, immediate control would save much more than it would cost and is amply justified on economic grounds.

Relationships and Procedures

Infection Buildup

The first task in estimating value saved is to determine the rate of infection to anticipate during the coming decade. Where rust is present in pine stands, the average number of trees infected per year typically increases with time, if there is no control. In a recent survey of blister-rust incidence, sample plots with different treatment histories were compared to determine how much infection rates increased after treatment.[1] Survey results are only tentative on this point, but there was little question that infection rates did increase with time, and that this increase was more rapid in areas of high climatic hazard than elsewhere.

[1] Marty, Robert. LOW AVERAGE BLISTER RUST INFECTION RATES MAY MEAN HIGH CONTROL COSTS. U.S. Forest Serv. Res. Note NE-28, 7 pp. Northeast. Forest Expt. Sta., Upper Darby, Pa., 1965.

The survey data indicated that the infection rate for the decade after examination will probably average about five times the rate observed for the 5-year period beginning 10 years before examination, in areas of high climatic hazard, and will typically average about three times greater for stands in low hazard areas.

These estimates of infection buildup are rather gross averages, and in the same general area there is considerable variation among stands having similar observed rates of infection. These differences in infection buildup are caused by differences in microclimate, in the species and distribution of ribes, in the size and distribution of pines, in the presence or absence of soil disturbance during the intervening period, and in other factors that cannot be taken into account at present. Figure 2 shows the location of the zones of high and low climatic hazard in the East. This figure was adapted from Charlton[2] and several unpublished sources.

The infection buildup relationship is shown in the upper right-hand graph in figure 1. A 5-year sample period beginning 10 years before examination is used to establish recent infection history because infections beginning during this period are more easily discernible than new infection at the time of examination. The sample-period infection rate must be established by actually checking a sample of trees from the pine area and noting how many were first infected during this period. Since infection rates are usually below 5 percent, a large number of trees must be examined to establish the infection rate accurately, and sample trees must be well distributed over the pine area.

Stocking Losses

Blister rust kills individual pines and groups of pines, thus reducing the proportion of the area actually stocked with pines. However, there is probably no significant reduction in yield until rust has created in the pine stand openings of at least 1/200 acre.

To see the effect of infection on stocking and yield, picture a pine stand subdivided into square plots 1/200 acre in size (fig. 3).

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[2] Charlton, John W. RELATING CLIMATE TO EASTERN WHITE PINE BLISTER RUST INFECTION HAZARD. U. S. Forest Serv. Eastern Region, 38 pp., illus. Upper Darby, Pa., 1963.

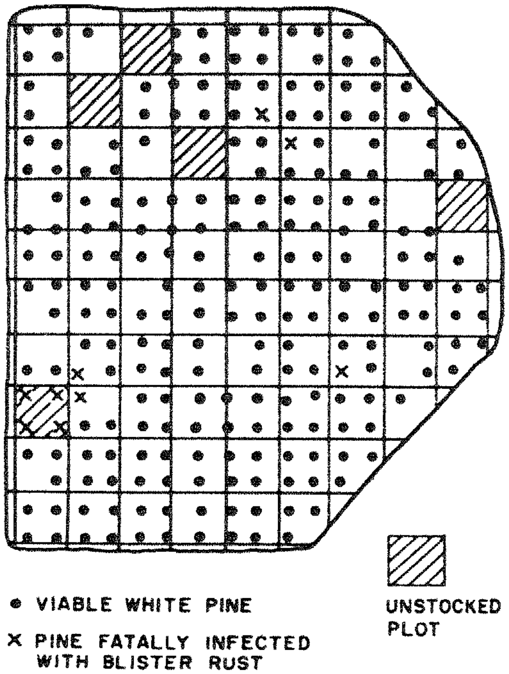

Figure 3. — Hypothetical distribution of pine stocking and rust infection in a young plantation.

If this stand is a young, unthinned plantation, originally planted at an 8-foot spacing, most of the plots will contain three or four pines. There will, of course, be some plots with only one or two pines, and even some without any pine, due to planting failures and subsequent mortality, including that caused by blister-rust infection in past years.

What is important as far as yield loss is concerned is how many of the plots now occupied by pines will be denuded by blister rust during the coming decade. If blister rust kills some but not all of the pines in a plot, probably no significant yield loss will result, because there is still at least one crop tree to occupy the plot. But if rust kills all the pine on a plot, then the percentage of the stand area that will support pine at harvest has been reduced, and so yield will be reduced as well. If 10 of the 1/200-acre plots are denuded per acre during the next decade (fig. 3), this means about a 5-percent reduction in stand area occupied by pine and a similar loss in harvest yield.

The proportion of the pine area that will be denuded by blister rust in the decade after examination depends on the rate of infection during that period and the density and distribution of pine in the pine area. This relationship is shown in the upper left hand graph of figure 1. The graph shows that, as average density decreases, more area is denuded by a given amount of infection — on the average. Thus, lightly stocked stands are more seriously affected by rust because, in the extreme case where there are only 200 pines per acre, nearly every tree infected means a loss in harvest volume.

On the other hand, heavily stocked stands can lose many trees without reducing the number of uninfected pines to a critical level. This relationship implies that infection may often be more serious and damaging in older, lightly stocked poletimber stands than it is in young, densely stocked stands of reproduction.

There is a separate set of curves for plantations and natural stands in figure 1. The curves show that natural stands have more area denuded by a given level of infection than plantations with the same average density of pine stocking. This is because the distribution of pine stocking is usually more regular in plantations than in natural stands, and this means that natural stands will have larger areas of critically light stocking than do plantations of the same average density.

These curves, showing the relationship between infection rate and area denuded, are based on specific assumptions. The curves for plantations assume that the pine stocking is evenly distributed and that the infection is randomly distributed over one-half the pine area. The curves for natural stands assume that pine stocking follows the Poisson distribution and, again, that the infection is randomly distributed over one-half the pine area.

It is necessary to estimate the average density of pine during control-site evaluation. This is done by taking a sample of 1/200-acre plots, well distributed over the pine area, and observing the number of uninfected free-to-grow pine on each. This sample should be taken at the same time, and in conjunction with, the infection-rate sample. Count as viable stocking only those pines that have not yet contracted a fatal blister-rust infection and are free of other fatal insect and disease conditions as well. Also exclude pines that are shaded by trees of the more tolerant species shown in the following listing, unless a pine release treatment is planned for the stand: hemlock, balsam fir, spruce, maple, beech, yellow birch, and — for areas with site indices of 60 or better for pine — the oaks and hickories.

The density survey will provide two needed statistics, the proportion of sample plots without any viable pine stocking, and the average number of uninfected, free-to-grow pines on the remaining occupied plots.

Yield Losses

How much harvest yield will be lost if 10 percent of the stand area now occupied by pine is denuded by blister rust during the next decade? It is assumed here that 10 percent of the harvest yield will be lost under these circumstances, but what this means in board feet depends on stand growth rates and on rotation age. Table 1 shows how average net yield varies with site index and rotation age. These yield estimates are based on normal yield-table data, but are adjusted for an average level of volume loss due to weather and pest losses other than blister rust. Yields can be conditioned further by various silvicultural treatments, but these are ignored here. The yield estimates essentially apply to unmanaged stands.

Since the control worker cannot know what rotation age will actually be chosen at the time he examines the stand, rotation age is assumed here to be a function of both ownership and site index. Stands on poor sites are assumed to be held to age 80 by the typical private owner, to 70 years on medium sites, and to 60 years for good sites. Rotation ages on public lands are assumed to be 20 years longer on all sites.

For a given percentage of stocked area preserved by control, harvest volume saved increases as site index increases and is greater for public ownerships where stands are assumed to be held to older ages (fig. 1, lower left). The volume saved by control, shown in this graph, is expressed as an average saving per stocked acre.

Value Saved

The value of the additional yield that can be saved by early control depends on the stumpage value at harvest, the number of years to harvest, and the discount rate. Stumpage value per thousand board feet determines the total value of yield saved at the time of harvest.

The appropriate unit stumpage value for public programs is the conversion surplus for the stumpage, since this includes the addition to income for both the stumpage producer and the processor, and approximates the total increase in income for the economy. This unit value is assumed to be $30 per thousand board feet. This is somewhat higher than current stumpage prices in most market areas, but not unduly high when it is remembered that this value is for stands maturing many years hence, and includes the processor's profit margin in addition to stumpage price.

A second price assumption of $40 per thousand board feet is also used in this study. This price level was introduced to apply to stands that are being protected from white-pine weevil injury as well as from blister rust. The additional $10 is meant to be a conservative estimate of the increase in unit value that weevil control brings. The increase in volume resulting from weevil control is ignored, although this can also be substantial. The effect of weevil control is to make blister-rust control more effective because rust control saves more volume and value in an unweeviled stand. The crop trees preserved from blister-rust infection are of better quality in stands protected from weevil injury, and their merchantable volumes may be larger as well. A similar increase in unit value could be claimed for pruned stands, but this is not taken into account in this study.

Value saved at harvest must be discounted to the present in order to compare it with the cost of control. A 4-percent discount rate is used here because it approximates the rate of interest currently paid on negotiable interest-bearing securities of the United States. Public investments should return at least this rate of interest. The number of years that value saved at harvest must be discounted is given by the assumed rotation age less present stand age.

These relationships are shown in the lower right hand graph of figure 1. The graph shows that for a given saving in harvest volume, stands closest to harvest have the largest present worth of value saved. Once again, the present worth of value saved is expressed on a per-stocked-acre basis.

Comparing Value Saved with Control Cost

The present worth of value saved, by not delaying rust control 10 years, is to be compared with the estimated cost of immediate treatment. If the present worth of value saved is greater than the expected cost of control, then immediate control will produce enough additional harvest value to return more than 4 percent on control costs, and the operation is economically justified. If control cost exceeds the present worth of value saved, control is best postponed — at least until the next examination.

Control personnel are experienced and adept at estimating the crew-time required to destroy the ribes in and around pine areas. Two simple steps are needed to convert this total control-time estimate to an equivalent control cost per stocked acre. First total man-days must be converted to a per-stocked-acre basis. For example, if it will take a 4-man crew 2 days (a total of 8 man-days) to strip a control area of ribes, and the operation will protect a 50-acre pine area, four-fifths of which supports pine stocking, then the crew-time per stocked acre works out to 0.2 man-days (8 man-days ÷ 40 stocked acres). The final step is to multiply the estimates of man-days per stocked acre by $26, giving $5.20 per stocked acre ($26 x 0.2 man-days) as the control cost in this case.

The $26 per man-day is the average cost per man-day of Ribes eradication work in the states making up Forest Service Region Seven for the years 1961-63. It was compiled by dividing total zone and district expenditures for all rust control activities by the number of man-days spent in actual eradication work. Thus it includes costs of supervision, equipment, and other overhead expenses at the district and zone levels, as well as direct labor and materials costs.

Summary

The information in this paper provides an objective and reasoned basis for evaluating opportunities for blister rust control in white pine stands of the eastern United States. The evaluation procedures lead to an estimate of the value saved by instituting an immediate control treatment rather than postponing treatment 10 years. This estimate of value saved is discounted and compared with expected control cost. Immediate control is economically justified when the present worth of value saved exceeds the cost of control.

In developing this procedure, I have attempted to strike a reasonable balance between a complete consideration of all relevant determinants and ease in field application. Some determinants that are relatively unimportant, or are difficult to measure or predict, are ignored or held constant in the analysis. Other important determinants are treated as variables, and their values must be determined individually at each application. This will not be difficult for most variables, but some type of sampling of pine for infection rate and density seems unavoidable. All in all, then, these procedures mean that somewhat more time and effort will be required for the periodic examination phase of the rust-control program. This, I hope, will be amply repaid by its allowing subsequent control efforts to be directed more nearly toward those control areas that will benefit most.

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