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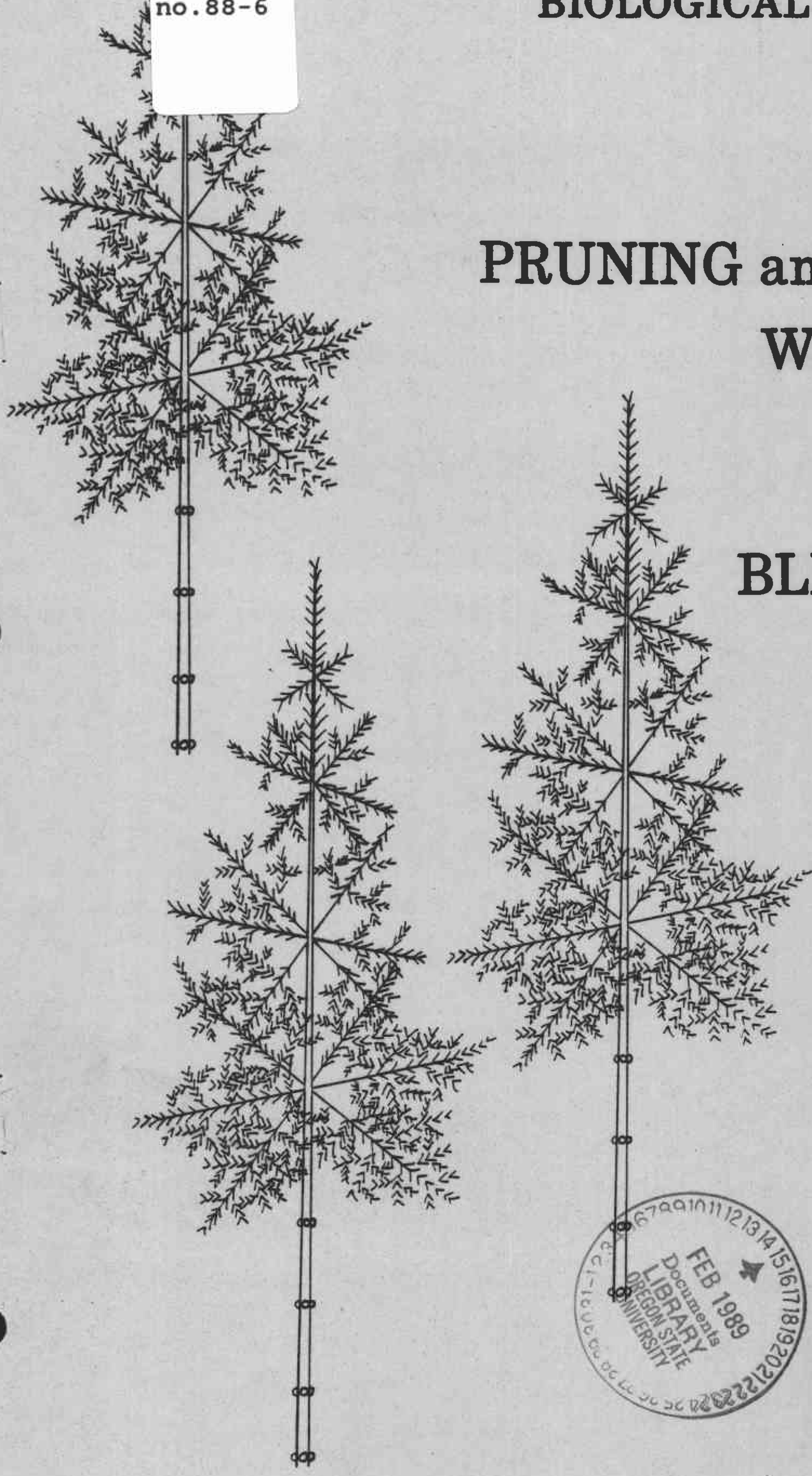
BIOLOGICAL and ECONOMIC FEASIBILITY of PRUNING and EXCISING WHITE PINES for BLISTER RUST CONTROL



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Susan K. Hagle
John L. Grasham

USDA Forest Service
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Report 88-6
1988

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BIOLOGICAL AND ECONOMIC FEASIBILITY OF PRUNING AND EXCISING WHITE PINES FOR BLISTER RUST CONTROL

Susan K. Hagle
John L. Grasham

Plant pathologist, USDA Forest Service, Northern Region, Timber, Cooperative Forestry and Pest Management; and Forestry Technician, USDA Forest Service, Northern Region, Palouse Ranger District.

ABSTRACT

White pine plantations which were established in 1968 on 88 acres of the Palouse Ranger District, Clearwater National Forest, were treated by pruning and canker excision to remove lethal white pine blister rust cankers. The success rate 15 months after treatment was 98 percent for pruning and 81 percent for excisions. Future growth and development of the stands were projected using a stand growth model. Economic analysis based upon these projections yielded positive benefit/cost ratios for both pruning alone and pruning with canker excision.

INTRODUCTION

There are thousands of acres of white pine plantations in the Northern Region which were established in the 1950's and 1960's. Most of them are now in conditions in which a substantial proportion of the white pines have died or will die from blister rust (*Cronartium ribicola* Fisch.) infection if they do not receive treatment to remove lethal cankers. The stands evaluated in this report were such stands. Initial observation suggested that they still had major components of white pine surviving, the white pines were larger and growing faster than the other major component (grand fir), and most of the white pines had potentially lethal infections. Treatment of rust-infected white pines to remove infections consists of two possibilities; prune away infected branches and excise stem cankers.

Much was written in the 1950's and 1960's about the potential gains from pruning white pines to improve wood quality. Funk (1961) reviewed literature pertaining to pruning eastern white pine concluding that plantations should be pruned except on poor sites. His conclusion was based upon the improvement in wood quality resulting from pruning compared to the expense of the operation; blister rust control was not a consideration. King and others (1960), in an economic analysis of white pine blister rust control in the Lake States, extolled the benefits of pruning from the standpoint of wood quality but also stated that the value of pines saved from blister rust exceeded the cost of pruning by four times.

Licke (Putnam 1956) studied the benefits of pruning 8500 14-year-old eastern white pine in Minnesota to reduce blister rust-caused mortality. Pruning to one-half each tree height of all infected, prunable trees (without stem cankers), resulted in saving 7,700 of the sampled trees. Nine percent of the pruned trees died from infections which were above the pruning height or too close to the stem to be pruned away, or occurred on branches in the bottom whorl which were inadvertently missed by the crews.

Weber (1964) re-examined a stand 12 years after 200 crop trees per acre were pruned to control blister rust. They had been pruned to a height of 4 feet when they were 14 years old and averaged 10 feet tall. He found 13 percent of the pruned trees lethally infected. The unpruned trees were 30 percent lethally infected.

Weber (1964) also tested repeated pruning to protect eastern white pines in a high rust hazard area (Van Arsdel 1961) of Wisconsin. Beginning with 3-year old trees, he pruned biannually for a total of four prunings. The pruned trees were 19 percent lethally infected after four prunings while the unpruned trees were 59 percent lethally infected.

Pruning to control blister rust damage is currently recommended by Nichols and Anderson (1977) for the Lake States. Based on a report by Brown (1972), they designated lower limits of annual lethal infection rates for stands which are appropriate to prune for blister rust control. The limits ranged from one percent per year in stands with 200-299 white pines per acre, up to 10 percent per year for stands with more than 850 white pines per acre. Infection rates below the minimum were considered acceptable and not requiring pruning for control. They recommend that the first pruning take place at 4 years of age and that pruned trees be re-examined every 10 years until the lower 9 feet of the stems were free of live limbs. This recommendation is based upon the observation that the upper limit for most blister rust infection in the Lake States is about 9 feet.

Potential benefits from pruning western white pines in British Columbia were evaluated by Hunt (1982). He found that most cankers occured within 2.5 m (8.2 ft) of the ground and originated in branches. This was somewhat influenced by slope. Steeper slopes resulted in cankers occurring higher in crowns. Nonetheless, he concluded that most stands would benefit from pruning if treated before most cankers had reached the stems. A single pruning when trees are 2.5 to 5 m (16.4 ft) tall was recommended for white pines where they occur as a minor component of a stand. In stands where white pine is a major component, two prunings were recommended; the first when the trees are about 2.5 m tall and the second when they are 4 m (13.1 ft) tall, removing about half of the live crown each time.

We evaluated the biological and economic feasibility of treating 88 acres of 18-year old white pine plantations to control white pine blister rust by pruning and excising cankers from crop trees. To be considered feasible, the project was required to produce at least a 75 percent of treated trees free of lethal infection and a positive benefit/cost ratio at merchantability of the white pine component. We set merchantability at 90 percent of white pine crop trees equalling or exceeding 8 inches d.b.h.

METHODS

Stand treatment

Intermediate treatment of western white pine in three stands to reduce white pine blister rust infection was completed in June 1985 on the Palouse Ranger District of the Clearwater National Forest. The project cost was $5,000 including the purchase of supplies, travel, and crew wages. Forty-five person days were required to treat 88 acres.

The tools required for the job included pruning shears with 2-foot handles, folding pruning saws, and tree scribes. Treatment was done in June to take advantage of fungus sporulation and fresh resin flow from cankers which made detection of cankers and location of canker margins easier.

Perhaps the most critical phase of the operation was selection of trees to be treated. Dominant and codominant trees on about an 8-foot spacing were selected. It was critical to examine the base of the tree for a basal canker before proceeding with treatment. The stem was then inspected for cankers and judged treatable or not. If excision would have girdled more than 50 percent of the circumference of the tree, it was not treatable and the operator moved on to the next candidate. Trees were examined high in the crown as well. No trees were climbed for treatment; both excised cankers and pathologically pruned branches (infected branches removed above the standard pruning height) had to be within reach of the operator from the ground to be treated. If potentially lethal cankers were seen in branches too high to prune away or on the stem too high to be excised, the tree was rejected.

Once the inspection was completed and the decision made to treat the tree, treatment always began with pruning to one-half the tree height. Limbs were removed at the branch collar. This was followed by pathological pruning of any lethal infections in branches above the standard pruning height. If the tree required excision of a canker, this was done next by the same operator. Trees with limb cankers of which the innermost margin was within 6 inches of the bole, were excised after pruning. The excision involved scribing a channel completely through the cambium 2 inches beyond and surrounding the the branch collar. Bole cankers were excised in a similar manner 2 inches beyond the visible edge of the canker. In some cases, two bole cankers were excised. In these cases the sum of the excisions could not exceed 50 percent of the circumference of the bole.

Evaluation plots

Plots were established 15 months after the treatment had been completed to monitor success of the treatments. Sixteen square 1/20-acre permanent plots were located on a grid over the three stands. All white pines which were at least 4.5 feet in height were labeled with numbered metal tags. Height, diameter, and damage information was recorded for each tree as presented in Table 1. All other trees with heights of at least 4.5 feet on each plot were tallied and their heights and diameters recorded. Presence of damage was recorded by cause for these trees as well.

Table 1.--Damage information recorded for all trees on plots.

WHITE PINES

Treated

Height pruned

Number of branches pathologically pruned.

Excised cankers; complete or incomplete excision, percent girdle after excision
Missed cankers; number of basal cankers missed, number of bole cankers missed below 6 feet on stem, number of bole cankers missed above 6 feet on stem, number of branch cankers missed below 8 feet, number of branch cankers missed above 8 feet, lethal branch cankers missed, nonlethal branch cankers missed.
Presence of other diseases or insect damage.

Untreated

Number of basal cankers.
Number of bole cankers below 6 feet.
Number of bole cankers above 6 feet.
Number of branch cankers below 8 feet.
Number of branch cankers above 8 feet.
Lethal branch cankers, nonlethal branch cankers.
Presence of other diseases or insect damage.

Other tree species

Presence of diseases or insect damage.

Stand growth and development projections

Version 5.2 of the Stand Prognosis Model developed by Stage (1973) and Wykoff and others (1982) was used to project the growth and development of the stands over a 100-year period. The three stands covered a continuous area. They had similar habitat types and histories and had been planted in the same year using the same seed source. For these reasons, the tree lists for the three stands were combined to produce a single list for the Prognosis Model projections. The projections were made with three scenarios based on treatment of rust-infected trees. In the first projection (1) we eliminated all lethally infected white pines from the tree list. This included those which had not been treated and were lethally infected as well as those which had been unsuccessfully treated. This simulates the current condition of the stand except that the lethally infected trees would, in reality, have died slowly over about a 10-year period. For the second projection (2) we eliminated all lethally infected white pines and all white pines which had been excised. This was to test the result of pruning but not excising the stand. For the third projection (3) we eliminated all except 10 percent of the white pines on the tree list. This was done by selecting the first 19 uninfected white pines which had not received excision and eliminating all others from the list.

Economic analysis

We used the CHEAPO II model developed by Madema and Hatch (1982) and Horn and others (1986) for present net value analysis of the stand treatments. The CHEAPO II model is designed for economic analysis of Stand Prognosis Model outputs. Our economic assumptions included 1987 Clearwater National Forest average stumpage rates for trees 8 inches d.b.h. and larger with no value rate changes. These values in dollars per thousand board feet were: western larch = 76.70, western redcedar = 166.48, grand fir = 48.40, Douglas-fir = 81.56, and western white pine= 154.98. We used a real discount rate of 4 percent. Treatment costs were $56.82/acre for pruning and excision, $45.46/acre for pruning alone and $0 for no treatment. These costs were imposed in 1985.

RESULTS

The stands had an average of 921 trees per acre that were at least 4.5 feet tall. Stand composition averaged 50 percent grand fir, 27 percent western white pine, 11 percent western redcedar, 9 percent Douglas-fir and 3 percent western larch (Table 2). Of the trees which were at least 4.5 feet tall, species other than white pine averaged 1.1 inches d.b.h., and 8.3 feet tall. The white pines averaged considerably larger than the remainder of the stand. White pine diameters ranged from 0.2 to 8.2 inches, averaging 3.4 inches. The trees ranged from 5 to 34 feet in height, averaging 19 feet.

Table 2.--Species composition and mean diameters and heights by species averaged for the three stands treated. (* = diameter at breast height; ** = height).

Species	Trees/acre	Mean d.b.h.* in. (cm)	Mean Ht.** in. (m)
GF	460	1.3 (3.3)	10 (3.1
WP	244	3.4 (8.6)	19 (5.8)
WRC	105	0.9 (2.3)	8 (2.4)
DF	83	3.1 (7.9)	18 (5.5)
WL	29	3.7 (9.4)	25 (7.6)
TOTAL	921	2.1 (5.3)	13 (3.9)

There were some differences in stocking and species composition among the three stands. Stocking density of trees at least 4.5 feet tall ranged from 1003 TPA in stand 4 and 957 TPA in stand 3 to 500 TPA in stand 1. The white pine proportion also varied from 18 percent in stand 4, to 34 and 30 percent in stands 3 and 1, respectively. Because of the lower stocking density and high proportion of white pine, the white pine component is clearly more critical to stand 1 than stand 4. Total white pine per acre numbered 174 in stand 4, 340 in stand 3, and 43 in stand 1. However, the percent of white pines treated in each stand did not vary greatly. Treated trees were 43, 43 and 47 percent of the white pines in stands 4, 3 and 1, respectively.

Of a total of 195 white pines in the sample, 84 were pruned (Table 3). These represent 244 and 105 TPA, respectively. The pruned white pines averaged 4.1 inches in diameter and 22.6 feet height compared to 2.9 average d.b.h. and 16 feet height average for untreated white pines. Most of the treated trees were from the original plantation but some smaller, obviously ingrowth trees were treated. Few of these received treatment beyond pruning.

Table 3.--Summary of results of pruning and excision 15 months following treatment. (* = trees per acre; ** = diameter at breast height.)

	Lethally infected	Not lethally infected		Total	
	TPA *	TPA	X D.B.H.***	TPA	X D.B.H.
Treated	13	93	4.0 (10.2)	105	4.1 (10.4)
Not treated	126	13	1.2 (3.1)	139	3.4 (8.6)
Total	139	106	3.7 (9.4)	244	3.7 (9.4)

Treated trees were pruned to an average height of 5.2 feet but ranged from 1 to 8 feet. Twenty-seven percent of the pruned trees required additional branches removed by pathological pruning above the standard pruning height. The average number of branches removed above the standard pruning height on trees which required pathological pruning was 1.4 but ranged as high as eight in one case.

Canker excision was performed on 32 percent of the pruned trees, representing 34 TPA (Table 4). Excised white pines averaged 5.2 inches d.b.h. and 26.4 feet in height compared to 3.1 d.b.h. and 17.8 height averages for nonexcised white pines. Two cankers were excised on 22 percent of the excised trees (7.5 TPA). Excisions girdled an average of 24 percent (range 10-50) of the stem of treated trees. This includes the combined girdle of two excised cankers.

Effectiveness of pruning was very high (Figure 1). Only 2 percent of the trees which were pruned but not excised had lethal cankers remaining. There were an average of 0.08 missed lethal branch cankers remaining on pruned trees. These were all on two trees. Of the total of eight missed lethal branch cankers, six were high in the crowns, above 8 feet.

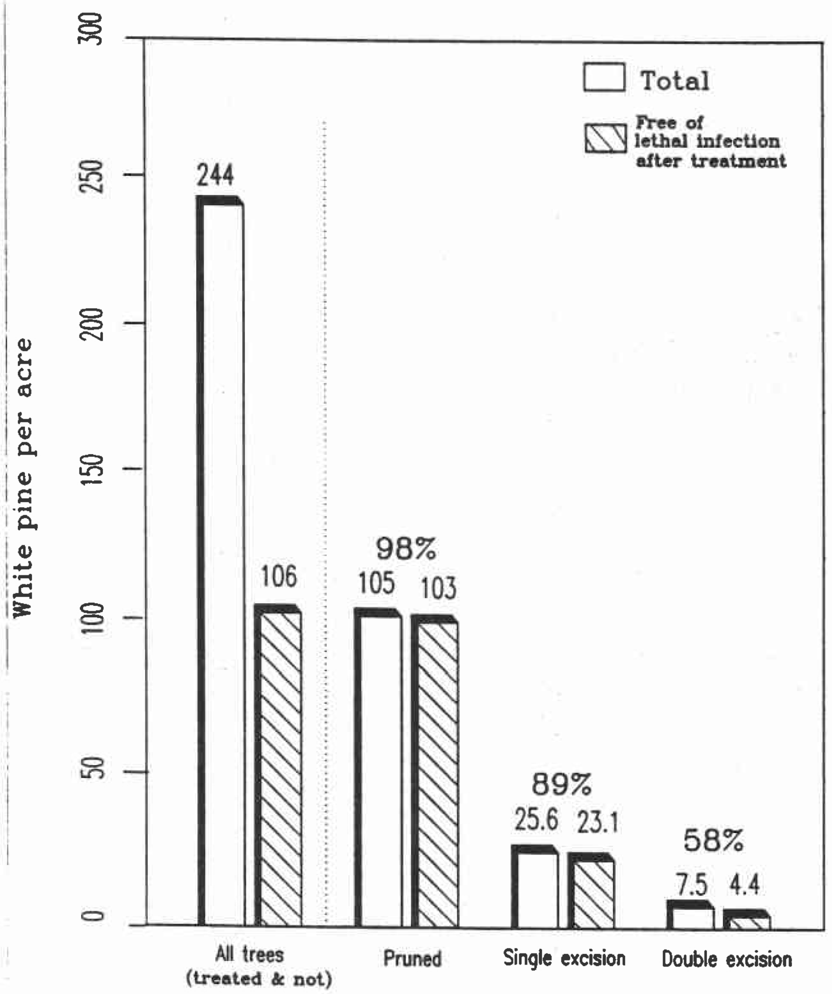
Overall, 12 percent of the treated trees had lethal infections remaining. Most of these were the result of incomplete excisions or basal cankers which had been overlooked.

Canker excision was completely successful in 81 percent of the excised trees. Excision of two cankers on one tree resulted in approximately twice the failure rate of one excision (Figure 1).

Table 4.--Lethal infections remaining on white pines 15 months following canker treatment.

		TREATED WWP				
Plot	Total WWP	Pruned	Excised	Excision Incomplete	Missed Lethal	Total Clean
01	12	7	5	0	0	7
02	12	5	5	0	0	5
03	9	3	0	0	1	2
04	2	1	0	0	0	1
05	12	5	2	1	2	3
06	10	5	3	0	0	5
07	4	0	0	0	0	0
08	21	9	2	0	0	9
09	27	11	4	2	1	8
10	30	15	0	0	0	15
11	3	2	1	1	0	1
12	4	2	1	0	0	2
13	24	10	3	0	1	9
14	10	2	1	1	0	1
15	9	6	0	0	0	6
16	6	1	0	0	0	1
All	195	84	27	5	5	74
TPA	244	105	34			93
Percent	100	43	14	3	3	38
Percent of Treated		100	32	6	6	88

Figure 1.--Success of pruning, excising one canker per tree, or excising two cankers per tree.



Untreated white pines

Untreated white pines averaged 11 cankers per tree (range = 0 to 114). There was an average of six untreated white pines per plot. Average infection on plots ranged from 2 to 55 cankers per tree, indicating some tendency toward clumping of infections within plots as well as trees. Basal cankers were present on 49 percent, and non-basal stem cankers were present on 21 percent of the untreated trees. Untreated pines which were at least 10 years old averaged 0.00093 cankers per thousand needles per year. This indicates that the site has been in the low hazard category according to McDonald's White Pine Blister Rust Hazard Rating scale (Hagle and others, unpublished report, 1987).

Of 876 branch cankers present on untreated trees which were at least 20 feet tall, only eight branch cankers occured above 8 feet in the crowns. The remaining 868 branch cankers in these trees were all below 8 feet.

Other damages

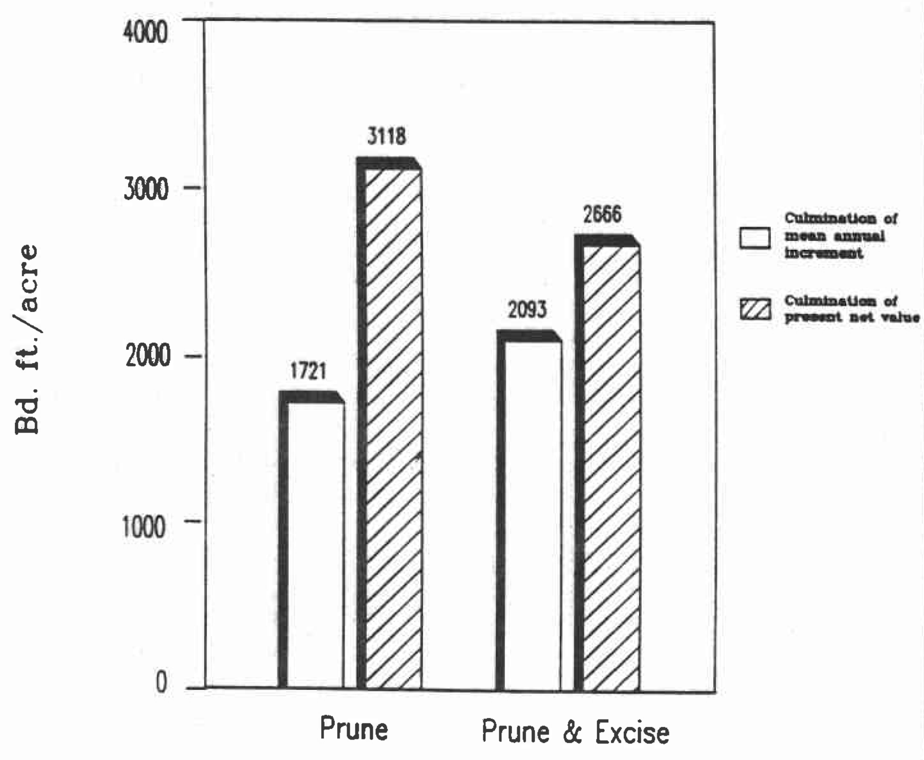
Root disease caused by *Armillaria ostoyae* (Romagn.) Herink was killing 1.3 live Douglas-fir per acre; 2 percent of the live Douglas-fir in the stand.

Red turpentine beetles (*Dendroctonus valens* LeConte) was a problem in some of the pruned trees. They had attacked 8.8 trees per acre, most of which were pruned trees. Seven percent of the pruned trees had been attacked by red turpentine beetles. No mortality had resulted from the attacks 1 year after pruning. Further monitoring will reveal whether survival of pruned trees has been jeopardized by the insect attacks.

Prognosis projections and economic analysis

Stand composition changes resulting from the loss of white pine in the no-treatment projections produced lower volumes than treatment projections. The stands were projected to reach merchantability (90 percent of white pine crop trees equal to or exceeding 8 inches d.b.h.) in 2025. In 2025, when present net value is greatest in all three projections, the board foot volumes per acre were 17,143, 16,771 and 15,050, respectively for pruned and excised, pruned but not excised, and untreated projections (Figure 2). In 2055, at culmination of mean annual increment (MAI), volumes were 33,228, 33,680, and 30,562, respectively.

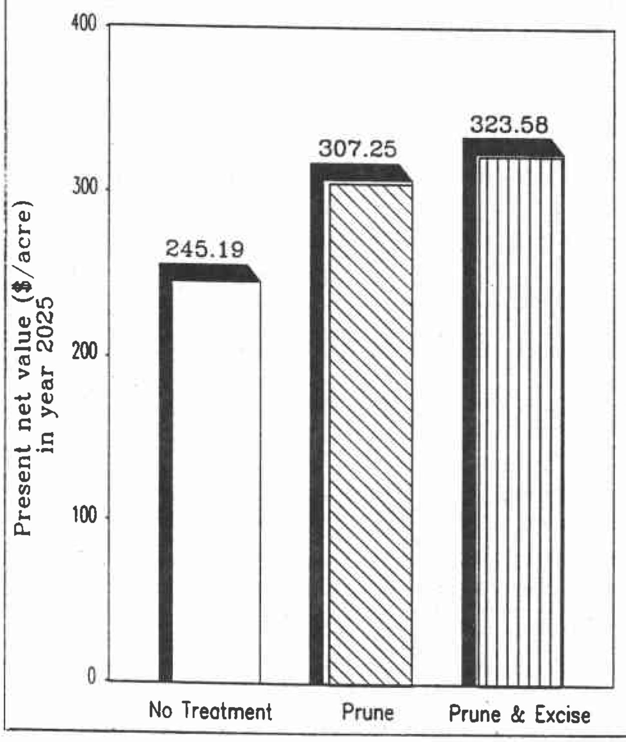
Figure 2.--Increase in volume productivity of all species in stands projected to year of greatest present net value (2025) and culmination of mean annual increment (2055).



Species composition of the merchantable board foot volume at culmination of MAI was 44 percent white pine, 32 percent grand fir and 16 percent Douglas-fir for the pruned and excised projection. Similarly, composition was 39 percent white pine, 37 percent grand fir and 17 percent Douglas-fir in the pruned but not excised projection. In the untreated projection, composition was quite different with only 12 percent white pine, 53 percent grand fir and 25 percent Douglas-fir.

The present net value of the stands, if harvested at age 58 (40 years from now), is projected to be $323.58 per acre if pruned and excised, $307.25 per acre if pruned but not excised, and $245.19 per acre if left untreated (Figure 3). The present net value at culmination of mean annual increment in 2055 is projected to be $173.38 per acre if pruned and excised, $175.80 if pruned but not excised, and $151.69 per acre if left untreated.

Figure 3.--Present net value of stands in 2025; the year in which present net value is projected to culminate for each treatment method.



DISCUSSION

Biological feasibility

These results demonstrate that pruning and canker excision are both biologically feasible methods to reduce blister rust infection. Success of pruning alone was somewhat higher than success rate reported by Licke (Putnam 1956). Ninety-two percent of the 14-year-old trees were free of lethal infection after pruning in Licke's study compared to 98 percent in this study. Success rates in Weber's study (Weber 1964) may have been comparable to ours 1 year after pruning because even 12 years after pruning there was only 13 percent lethal infection in pruned trees.

Most potentially lethal infection occurs early in the life of a stand. Factors which probably contribute to this phenomenon include: (1) presence of live branches near the ground where conditions for infection may be best (Van Arsdel 1961), (2) proportionally more of the suceptible foliage is close to the stem, (3) and the local *Ribes* population is likely to be at it's peak following site disturbance (Moss and Wellner 1953). Timing of treatment can greatly influence the effectiveness and the cost of treatment. As in this stand, most infections are concentrated in the lower half to third of the tree height and nearly all cankers in the stand were within 8 feet of the ground. This is similar to Hunt's findings in British Columbia (1982) where most cankers occured within 8.2 feet (2.5 m) of the ground.

Hunt (1982) recommended double pruning where white pine was a major component of stands. We concur with his findings; the stands in this study would undoubtedly have benefitted more from pruning earlier, before many cankers had invaded the stems. Earlier pruning would have stopped many more branch cankers from reaching the stem and allowed excision of cankers from many trees which were no longer savable in 1985. However, if a second pruning is not planned for a stand, there may be equal benefit from delaying pruning until until the trees are larger and pruning will allow removal of most branches within 8 feet of the ground. This may reduce the likelihood of trees receiving new lethal infections.

Canker excision has seldom been practiced on an operational basis in forest stands. In fact, we were able to locate only one published report suggesting such a proceedure (Martin and Gravatt, 1942). Our analysis indicates that canker excision is biologically feasible as a procedure to rid trees of stem infections. Although the success rate for canker excision was lower than that for pruning (where only branch cankers are present), it was still reasonably high at 81 percent of excised trees rendered free of lethal infection. It does, however, imply that excision is a less reliable method of curing infected trees than is pruning and emphasizes the need to monitor stands closely to choose the best time to treat, i.e., before many cankers have entered the stem. We are unsure whether the difficulty with excision was due to inability to discern the margin between discolored and normal cambium or to the fungus actually existing more than 2 inches (5.1 cm) beyond this apparent canker margin. Ehrhlich and Opie (1940) measured the mycelial extent of *Cronartium ribicola* beyond the limits of surface discoloration of cankers. They found this value to vary considerably ranging from 0.19 to 1.2 inches (0.48 to 3.20 cm) with a mean of 0.66 $\pm$ 0.02 (1.66 $\pm$ 0.06) On this basis, it is doubtful that the mycelium extended more than 2 inches beyond the discoloration at the canker margin. It is more likely that an inability to discern the outermost discoloration of the canker margin accounts for most of the incomplete excisions. Performing the excisions during sporulation of the fungus and while there was fresh resin flow from cankers probably contributed to the reasonably high rate of success of excision. Wetting the canker margin or rubbing it with a cloth or brush might also have aided in detecting the discoloration.

The low rate of current new infection as indicated by the few cankers appearing above 8 feet in trees at least 20 feet tall indicates that this stand was a good candidate for canker treatment. The site fits the category of low rust hazard on the basis of total infection counts in untreated trees which are at least 10 years old (Hagle and others, unpublished report). We consider the stand to have a reasonably good chance of reaching merchantability and culmination of mean annual increment without serious losses to blister rust. Most lethal blister rust infections, 70 to 80 percent of the lethal infections occurring over a rotation, occur within the first 20 years of stand development in the Lake States (Brown 1972). Annual infection rates typically decline over time. Our observations agree with those from the Lake States. These stands incurred most of the potentially lethal infections within the first few years of development as indicated by the high percentage of basal cankers. There were no *Ribes* plants encountered in any of the stands during plot establishment. This does not imply that there had not been *Ribes* present earlier in the development of the stand. There probably was a modest population which has largely died out as the planted pines have grown and natural regeneration has filled in. The low *Ribes* population is expected to contribute to continued low new infection rates.

Economic feasibility

Planted white pine makes up the vast majority of the largest trees in the stand. Retention or loss of these trees effects both the volume and value of the stands in projections. Canker excision only increased the white pine component by 5 percent in the projection to 2055, with little difference in merchantable volume. The largest 10 percent of the trees were, however, projected to average 4 inches larger with excision than without. This is probably because the average tree receiving excision was 1.1 inches greater in diameter at breast height at the beginning of the projections than were the pruned but not excised trees.

Growth rates in the untreated projection are somewhat exaggerated because we removed all except 10 percent of the white pine from the tree list before starting the projections. In reality, the white pines would have died slowly and may have posed a significant obstruction to growth of the other, mostly understory, trees. However, the values produced by the Stand Prognosis Model projections are in keeping, in trend and relative magnitude, with our expectations for the stands.

Decay impact in the grand fir and root disease impact in both the Douglas-fir and grand fir components is not accounted for in our projections. The high proportion of grand fir and Douglas fir resulting from the untreated stand projection indicates that the untreated stand could incur substantial losses from root disease over the remainder of the rotation. White pine generally is not as susceptible to Armillaria root disease as are grand fir and Douglas-fir so the larger the white pine component in the stands, the lower the root disease losses are likely to be.

The main point in the economic analysis was not to demonstrate which treatment (including no-treatment) was economically most desirable, but rather to demonstrate that these white pine stands could be treated by pruning and by pruning with excision and yield positive benefit/cost ratios at culmination of mean annual increment. The benefit/cost ratios in 2025 and 2055 were 6.9 and 4.2, respectively for stands receiving pruning and excision. They were 8.0 and 5.0, respectively for pruning without excision. We used current (1987) stumpage values because they were consistent with relative stumpage rates for the past 20 years and because we wanted to avoid introducing personal bias by assigning stumpage values which have not been documented to exist on the Forest.

There are benefits of retaining the white pine component in these stands which are not easily assigned dollar values. They are among a relatively few stands in their age class in this Region which have retained a significant white pine component. They will provide both visual and product diversity for the age class. They are likely to reduce the losses from root disease that otherwise would be expected in the stand with a minor component of white pine. They also contribute to white pine genetic diversity by representing genotypes not present among the seed orchard trees in the tree improvement program.

CONCLUSIONS

White pines were treated in these stands by pruning and stem canker excision with high levels of both biological and economic feasibility.

Several factors probably contributed to biological feasability of the project.

1. Two-thirds of the treatable trees could be rendered free of lethal infection by pruning alone. Since pruning was more successful than canker excision for treating infected trees, a high proportion of trees which do not require excision can be expected to yeild higher sucess rates. Treating the stand earlier would have allowed treatment of more trees by pruning, but would have left the stand in higher risk of new lethal infection in the lower branches.

2. The rust hazard in the stands was low and few new infections have developed in recent years.

3. Treatment was accomplished when the cankers were most visible which probably increased detection efficiency.

4. The crew was trained and supervised by an individual who was very familiar with blister rust cankers.

5. The sequence of inspection and treatment used by the crew minimized the incidence of treatment of trees with untreatable, lethal cankers.

Several factors contributed to economic feasiblity of the project.

1. Although the stocking of treatable white pines was low (105 TPA), it was sufficient to yield a substantial component of treated white pines (44 percent of crop trees).

2. The non-white pine components of the stands had a mean diameter and a mean height which were considerably less than those of the white pine component.

3. The major non-white pine component of the stands was grand fir which historically has generated lower stumpage rates than white pine.

This project serves as an example of how pruning and excising can be used to control blister rust. We highly recommend surveying stands considered for such treatment before the decision is made to treat them. The feasibility of such projects can be analyzed from surveys which reveal the status of the rust cankers in the stands and the relative importance of white pine as a stand component.

The concern will remain after treating a stand, that conditions might change and a stand with a history of low rust hazard will recieve sufficient new cankers to threaten the investment. Certainly, disturbance of nearby sites which potentially have high populations of *Ribes* could increase infection rates and cause heavy losses of treated white pines. The possible consequences of such operations should be considered before proceeding with canker treatment and before disturbing nearby sites after treatment.

Weather patterns exert some control over fungus sporulation and infection success. Weather patterns which favor sporulation and infection could dramatically increase infection rates at any time in the rotation. These effects are not predictable and may render the stand in need of a second pruning or, if occurring after trees are too tall to prune out new infections, untreatable. Selection of stands on low hazard sites for treatment is currently our best insurance against this possibility.

We plan to continue monitoring these stands for effectiveness of the treatment and for occurrences of new infections.

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