GIRDLING AS A MEANS OF REMOVING UNDESIRABLE TREE SPECIES IN THE WESTERN WHITE PINE TYPE[1]

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INTRODUCTION

Western hemlock (*Tsuga heterophylla*) and white or grand fir (*Abies grandis*), two shade-tolerating species which are found in more or less abundance in the western white pine type in northern Idaho and northwestern Montana, must usually be classified as undesirable species silviculturally, and for several reasons. In both species the liability to infection by heart-rot at an early age causes such a high percentage of defect that by the time the trees reach merchantable or saw-log size they are apt to be largely or entirely worthless. Even when sound, the material produced by these species is of poor quality and low value; and in stands in which they occur to any extent the stumpage yield per acre is materially decreased by the fact that they occupy space which might support more valuable species.

A particularly undesirable feature is the dense shade cast by these trees. The advance growth of hemlock and white fir seedlings and saplings which comes in under the mature trees has a tendency to monopolize the openings between the larger trees and to repel less shade-tolerant species. As a result, on cutting areas where seedlings, saplings, and larger trees of these species are present, it is difficult to obtain establishment and growth of reproduction of the more intolerant desirable species of western white pine (*Pinus monticola*) and western larch (*Larix occidentalis*).

In order to get maximum production of the most valuable species in future stands, the hemlock and white fir trees left standing on cut-over areas should be disposed of, and measures to prevent or hinder the reseeding of the ground by these species should be taken.

Possible methods of disposing of undesirable tree species include girdling, burning, and poisoning.

Killing trees by fire is particularly effective with thin-barked species, such as hemlock and white fir. Fire may be applied by burning piles of forest débris at the base of undesirable trees, or in thickets; or it may be applied as broadcast burning of slashings, which destroys most or all of the undesirable reproduction and larger trees. Broadcast burning, however, in most cases destroys also the valuable seed trees and trees left for increased growth, as well as most or all of the seed stored in the surface duff.

Poisoning, or introducing some toxic material into the tree through the sap, has been used to some extent for killing hardwood stump sprouts in farm clearings in the Eastern States. Although the poisoning method may very often be too expensive to be practicable, it offers possibilities worthy of investigation.

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Girdling, an old and common method, consists of so severing the cambium and phloem of the tree that the nutritive communication between root and crown is permanently interrupted.

EARLY ATTEMPTS AT KILLING BY GIRDLING

As far as known to the writers, the first attempt, apart from general broadcast burning, for the specific purpose of destroying undesirable white fir and hemlock on Forest Service sales, was in 1910, on the Kaniksu National Forest. Here the hemlock and white fir were girdled in three seed plots, a belt of bark 2 to 3 feet high around the base of the tree being stripped off. The work was not done carefully and many strips of inner bark were left intact, connecting the root and the top. Consequently very few of the trees were killed and the wounded portion is gradually healing by the growth of new bark.

The objects of the girdling—to prevent seed production on the adjoining clean-cut area, and to lessen the shade in the seed plot—were both defeated, as the girdled trees produced heavy seed crops three years later, and the shade in the plots was not materially decreased.

The next work of the kind was on several cuttings in the white-pine type on the Coeur d'Alene National Forest, which was followed the next year by additional girdling on later sales. The method has since been specified for use in all white pine sales on the Coeur d'Alene Forest.

Two different forms of girdling were employed in these early trials. One was to strip off the bark around the base of the tree for a width of 2 to 3 feet, a method similar to that used on the Kaniksu National Forest. The other was to cut a notch 1 to 2 inches deep completely around the tree, with or without some stripping of the bark above or below the notch.

The stripping method was tried in the winter when the bark adhered so tightly that it would not peel but had to be cut off. The leaving of narrow strips of inner bark connecting the upper and lower ends of the wounds was, in many cases, unavoidable. The following year it was noticed that many of the hemlock and white fir trees which had been girdled by the notch or stripping methods still had green healthy tops and were bearing unusually heavy crops of cones. In order to determine whether the girdling had affected the fertility of these cones, two large hemlocks, one girdled by stripping and the other by notching, were cut, and a bushel of cones collected from each. Seed was extracted at the Northern Rocky Mountain Forest Experiment Station at room temperatures, never higher than 80° or 90° F., and duplicate tests of 500 seed each were made in sand flats in the experiment station greenhouse. The results are given in Table I.

TABLE I.—*Germination of duplicate samples of 500 seeds each from girdled hemlock trees*

Progress of germination	Number of days	Percentage of germination of seeds from—					
		Notch-girdled trees			Peeled trees		
		Test A	Test B	Average	Test A	Test B	Average
Beginning	19	11.2	5.0	8.1	0.8	0.2	0.5
Height	28	74.8	51.8	63.3	31.4	16.2	23.8
Last active	38	87.0	68.0	77.5	51.4	44.6	48.0
End	50	89.2	73.8	81.5	53.4	46.0	49.7

It is apparent from these tests that winter girdling, according to either the stripping or notching method, does not prevent the production of a crop of fertile hemlock seed the fall after girdling. Whether the girdling actually causes an increase in the amount of seed produced by these trees above the amount they would have borne if they had not been girdled is not definitely indicated. The crops from girdled trees appeared to be uniformly very heavy, but this occurred in an exceptionally good seed year for all species in the white pine region.

That the percentage of fertility of the seed from the tree girdled by stripping was but little more than half that shown by the tree girdled by notching, does not lead to any definite conclusion, for individual trees are known to vary widely in the quality of seed produced, regardless of external influences. The seed produced by the tree that had been stripped was sufficiently fertile (50 per cent) to restock the area effectively, so it is not possible to consider stripping the bark a better method than notching on the basis of this data. The other object of the girdling, the reduction of shade, was also defeated by the fact that the trees remained green all summer, at the time when white pine and larch seedlings were germinating and establishing themselves.

Thus during the first year after cutting, at the time when surface conditions for germination of desirable intolerant species are most favorable, the girdled hemlocks not only produced heavy crops of fertile seed, which on one particular area resulted in a stand of some 90,000 hemlock seedlings per acre by actual count, but also hindered by their shade the germination and establishment of intolerant white pine and larch on a considerable portion of the area.

Particular note was taken of the effect during the second season after these girdling experiments. A great majority of the completely girdled trees showed a very unthrifty appearance, and this was true, apparently to an equal degree, of the trees girdled by either the notch or stripping method. The girdling on the stripped trees was, however, more often incomplete on account of the strips of inner bark left, and consequently the notch girdling was effective in a larger percentage of cases of the trees girdled.

On several of the sale areas where the girdling had been done, the brush had been burned in piles that autumn. It was noticed that this brush burning had been very effective in killing both large trees

of the undesirable species, and thickets of saplings and advanced growth. The effect of this burning had been immediate, causing the crowns to die and the leaves to fall off within a short time after the burning. The effect of heat and fire on saplings and reproduction was surprisingly great, whole thickets being completely killed by small fires which actually came in contact with only a small proportion of the trees. On the other hand, the trees which had been girdled but not burned were just beginning to die and lose their leaves at the end of the second growing season after girdling, and after they had produced one good seed crop. The much greater effectiveness and value of the brush burning, compared to girdling, were very apparent. From this it is thought that girdling had best be done after brush has been burned, in order to supplement the burning and reduce the cost of cleaning up the area.

For the purpose of finding a more effective way of killing the white fir and hemlock by girdling or other means, an experiment was later installed which was planned to take into account available information on the physiological functions of trees.

In the light of present knowledge of these functions it is easy to account for the fact that the two girdled hemlock trees from which seed was collected remained green throughout the summer following the girdling and produced heavy crops of seed. The girdling did not prevent the movement of water, soluble salts, and stored food from the roots through the sapwood to the leaves. Nourished thus with this water and stored food, it was possible for the foliage to continue photosynthetic manufacture of new food during the summer after girdling. Since most or all of the surplus food could not return to the roots for storage, because of the girdling of the inner bark, it remained in the trunk and crown and was doubtless available for the production of a heavy crop of seed.

There is reason to think, furthermore, that girdling does not entirely prevent the movement of surplus food from the foliage to the roots. This theory is advanced by S. B. Elliott,[2] who cites instances of white pines that have lived from 5 to 22 years after girdling.

EXPERIMENTS IN GIRDLING AND POISONING

As winter girdling had not proved entirely successful, it was decided to try girdling at different times during the growing season, when, in accordance with the theory of food movement, there would be a minimum of stored food in the sapwood available for the production of seed and continued growth. Accordingly, it was decided to test 10 trees each of white fir and hemlock on each of the following dates:

May 15 (beginning of active growth).
June 15 (height of active growth).
July 15 (slackening of growth).
August 15 (height of storing of surplus food).
September 15 (slackening of vegetative activity at end of growing season).

[2] ELLIOTT, S. B. THE PROBLEM OF FOOD MOVEMENT IN TREES. Forestry Quart. 12: 559–561. 1914.

One hundred trees, varying in size from 7 to 28 inches in diameter, and in crown class from intermediate to dominant, were selected in an overmature white pine stand on the Priest River experimental forest. The average diameter of the 50 hemlocks was 15 inches at breast height, while that of the 50 white firs was 13 inches. Heights varied from 70 to 115 feet, averaging 90 feet for both species. The range in age was from 100 to 200 years or more.

Four different methods of straight girdling were used on each date, as follows:

(1) Bark stripped off at base for a height of from 2 to 3 feet.

(2) Trunk girdled with an axe notch cut in the sapwood to a depth of from 1 to 2 inches.

(3) Bark stripped off at base for a distance of from 2 to 3 feet and an axe notch cut into the sapwood to a depth of from 1 to 2 inches, at about the middle of the stripped belt.

(4) Notch from 2 to 3 inches deep, cut through sapwood with a saw and chipped out with axe.

In addition to the girdling, poisoning experiments were begun on a small scale. The following three methods of introducing the poisonous material were used:

(1) Two short notches, 6 to 7 inches long and 2 to 3 inches deep, with their inner edges an inch or two lower than their outer edges were chopped into the sapwood on opposite sides of the tree. They were then filled with a saturated solution of either copper sulphate, copper acetate, or zinc chloride.

(2) Four auger holes, 2 inches in diameter and 3 inches deep, were bored at the base of the tree on opposite sides, and chemicals were put in the holes, as saturated solutions (in the May treatments) or in dry form with water added (as in the June and July treatments). The chemicals used in this treatment were copper sulphate, copper acetate, zinc chloride, copper carbonate, lye, and sodium chloride.

(3) A notch 1 to 2 inches deep was cut completely around the tree, as in method 2 for girdling only, and two 2-inch auger holes were bored at the base of the tree on opposite sides. These holes were filled with the same chemicals used in the foregoing test (2), a saturated solution being used in the May treatments and dry chemicals [3] with water added in June and July.

EFFECT ON FOLIAGE

Table II gives a summary of the effect of different treatments on the appearance of the foliage, in every instance where such an effect was noticeable at the end of the season.

[3] The reason for trying the dry chemicals was to see if the gradual dissolving and absorption into the sap would be any more effective than the rapid absorption of solution.

TABLE II.—*Effect of girdling and poisoning treatments during period of growth, as observed at end of season*

Treatment	Species	Date treated	Effect on tree		
			Unthrifty [a]	One-fourth dead [b]	Dead
GIRDLING					
Bark stripped off at base for distance of 24 to 40 inches.	Hemlock	May 15	1		
	do	June 15	1		
	White fir	do		1	
	do	Aug. 15		1	
Girdled with axe notch 1 to 2 inches deep	Hemlock	Sept. 15	1		
	do	May 15	1		
	do	June 15	1		
	White fir	do			1
	do	do		1	
	do	Aug. 15		1	
Barking and girdling combined	do	do	1		
Notch sawed and chipped 1 to 2 inches deep	Hemlock	June 15			1
POISONING					
Notches 6 to 7 inches long filled with saturated solution copper sulphate.	do	May 15	1		
Four 3-inch auger holes filled with saturated solution copper sulphate.	do	do	1		
Notches filled with saturated solution copper acetate.	do	do	1		
Girdling notch and two auger holes filled with dry lye.	White fir	July 17			1
No treatment control	Hemlock		1		
Total	Hemlock		9		1
	White fir		1	4	2

[a] Distinct yellow-green color of foliage.
[b] One-fourth of inner leaves dead.
[c] Almost dead or dead after Sept. 15.

The damaging influence of the treatments at the end of the first season was, on the whole, negligible. Of 85 trees treated (omitting 8 untreated control trees included in the series, and 7 trees blown down early in the season), only 16 showed any apparent effect whatever. Of these, only 3 had died (1 hemlock and 2 white firs). The other 13 trees (8 hemlocks and 5 white firs) appeared to be distinctly more yellow-green in color than their untreated neighbors, and showed more than the ordinary number of dead leaves. Not much importance can be attached, however, to this yellow-green appearance, as it may easily have been due to slight differences in exposure, soil, natural vigor of the tree, or other factors. The dying of inner leaves may have been just a natural shedding, as indicated by the fact that among the unthrifty trees was an untreated control tree. It is interesting to note, however, that the three trees which died were all girdled with a notch, two of them being axe notches and one a sawed notch. The percentage of the total basal area of the tree occupied by the notch ranged from 13.5 to 65.3, averaging 39.8 per cent for hemlock and 44 per cent for white fir. There seemed to be no relation between the death of the three dead trees and this percentage, the notches on the two white firs being below average and that on the hemlock somewhat above.

Chemicals had been used in only four cases out of the 16. In two cases hemlock trees which showed a yellow-green cast to the foliage had been treated in open-chopped notches—in one instance with a

saturated solution of copper sulphate, and in the other with a saturated solution of copper acetate. In another case a white fir which had been both completely girdled with an axe notch and treated with dry lye placed in two auger holes, died toward the end of the season. The fourth case, a hemlock, showed signs of unthriftiness after a saturated solution of copper sulphate had been placed in four 3-inch auger holes bored in the trunk.

Since the copper sulphate, copper acetate, and lye showed no apparent effect in the several other cases in which they were used, it is probable that they had little or no influence in these treatments. It was noted in the treatments where dry chemicals were used that the more easily soluble materials—zinc chloride, lye, and sodium chloride—had been entirely absorbed, while the copper sulphate, acetate, and carbonate, were only partially dissolved, the residue amounting to from one-fourth to one-half or more of the amount of chemicals used.

One indication of the effect of girdling, it was thought, would be the extent to which the sapwood had dried out, since this would show the degree of restriction of the circulation of water and stored food upward from the roots to the crown. Accordingly, the depth of drying at the last observation, on November 17, was determined for a majority of the girdled trees. Measurements were taken at the center of the stripped portions, and inward from the inner edge of the notches.

Considerable irregularity was noticed in different trees and at different points on the same tree. The dryness on the stripped trees extended from 0.1 to 1.1 inch with an average of 0.4 inch. In the case of the notched trees, the drying extended 0.75 inch to 2 inches in from the innermost point of notch, with an average of 1.1 inch. The depth of the notches ranged from 1 to 3.75 inches, averaging 1.7 inches. The average depth of drying on the notched trees was 2.8 inches compared to 0.4 inch on the stripped trees.

Taking 15 inches as the average diameter at the point of girdling, the average reduction in the amount of wood available for the transmission of water and sap was 60 per cent of the cross-sectional area of the trunk on the notched trees compared to 5 per cent on the stripped trees. This difference indicates that the notching causes a twelve times greater restriction in the passage of water and food than does the stripping, and probably accounts for the fact that the only trees which died were those which had been notched.

Careful observations were made in the fall with field glasses, but no new cones were seen on any of the trees, although several cones left from the preceding year's crop were noticed on some of the hemlocks. This failure of the seed crop can not be attributed to the treatment, however, since there was an almost complete failure of the seed crop of all species in the region that year, due, probably, to severe frosts late in June.

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TIME REQUIRED FOR TREATMENTS

The time required for each treatment was recorded. Table III gives the average figures obtained:

TABLE III.—*Time consumed in girdling experiments*

Kind of treatment	Western hemlock		White fir		Both species	
	Average d. b. h.[a]	Time per tree (1 man)	Average d. b. h.	Time per tree (1 man)	Average d. b. h.	Time per tree (1 man)
	Inches	*Minutes*	*Inches*	*Minutes*	*Inches*	*Minutes*
Bark stripped off	18	8	13	7	15	7
Girdled with ax notch	15	7	13	4	14	5
Stripped and girdled with notch	14	9	12	11	13	10
Girdled with sawed notch	14	11	11	11	12	11
2 to 4 chopped notches 7 inches long filled with chemical	12	8	13	5	12	6
4 auger holes 3 inches deep filled with chemical	14	10	13	9	13	9
Girdled with ax notch, 2 auger holes filled with chemical	16	10	12	8	14	9

[a] Diameter at breast height.

It is apparent from this record that the method of girdling with and ax notch was distinctly faster than any of the other methods, requiring an average of 5 minutes of one man's time to a tree compared to 7 minutes for the stripping method, 10 minutes for the combined stripping and notch methods, and 11 minutes for the sawed-notch method.

CONCLUSIONS

No definite conclusions can be drawn from this work as yet because of the small number of instances showing effects of these treatments, and also owing to the possibility of developing further and more satisfactory methods of eliminating undesirable hemlock and fir. It seems probable, however, that girdling with an ax notch is the most desirable method, both in respect to cost and effectiveness. Also it seems that girdling in the spring and early summer (April, May, and June) is more effective than girdling during the late summer or winter.

So far, burning as a means of getting rid of these trees has not been thoroughly investigated, and it is planned to carry out further work along this line in order to determine just how far elimination can be accomplished when the slash from timber sales is burned.