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**INVERT UNPRODUCTIVE
HARDWOOD STANDS TO
*DESIRABLE FOREST TYPES***

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WEST VIRGINIA UNIVERSITY AGRICULTURAL EXPERIMENT STATION

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Convert Unproductive Hardwood Stands to Desirable Forest Types

K. L. Carvell

Introduction

LESS than a century ago West Virginia was covered with hardwood and softwood forests as valuable and productive as any similar forest types in eastern United States. Yet, today, thousands of acres of forest land in this State produce no merchantable wood products. Many elements working together have caused this drastic change in the original characteristics and composition of these stands.

Many degenerate stands have resulted from lack of good forest management practices. Forest land has been cut-over repeatedly with regard for future timber crops. In each cutting all merchantable trees were removed. Only culls and undesirable species were left. Orthless stems occupied more and more space in these stands—areas that could otherwise be used for growing more valuable trees. Unless land improvement work is carried out, no wood products of commercial value will be harvested from these areas for many years.

Other unproductive stands have originated following the abandonment of pasture and agricultural land. Whenever no desirable seed source was present, these old fields gradually restocked with bird-disseminated species, such as hawthorn (*Crataegus* spp.), black gum (*Lycia sylvatica* Marsh), sassafras (*Sassafras albidum* [Nutt.] Nees), crab apple (*Pyrus coronaria* L.), black locust (*Robinia pseudacacia* L.), and hickory (*Rhus* spp.). Inadequate stocking and poor distribution of these individuals have resulted in development of wide crowns, which have spread over these sites, delaying the subsequent establishment of more desirable species. Many low-value hardwood stands now occupy sites of high potential value as forest land. The past productiveness of many of these sites can be ascertained by examining the growth rings on occasional old stumps.

In 1954 the West Virginia University Agricultural Experiment Station began a study to determine the most suitable method of converting undesirable hardwood stands of old-field origin to more desirable forest types. Although this study is not completed, many interesting facts

concerning stand conversion have become evident. This bulletin summarizes the results obtained after twenty, half-acre plots have been converted.

The area selected for this study is located in the Division of Forestry Woodlot in Monongalia County, West Virginia. This land, formerly used for pasture, was abandoned about 20 years ago. Over the years bird-disseminated species became established, producing a dense thicket of hawthorn, crab apple, sassafras, black locust, and sumac. The stocking and relatively unevenaged condition of this stand permitted large spreading crowns to develop and almost no natural pruning was taken place. A few of these trees were cut for fence posts during the summer of 1953, but the majority have no potential value for wood products.

Procedure

In converting these unproductive forests to desirable types, existing woody growth must be killed. This can be accomplished by bulldozing, cutting, or poisoning. The most expedient method will be that which adequately clears the site at the lowest cost.

Natural regeneration can be used in those stands in which sufficient desirable tree species have reached seed-producing age and are able to provide an adequate seed source immediately after the woody growth has been eliminated. Unfortunately, most immature stands which have developed on abandoned fields contain no desirable natural seed source. Artificial regeneration is necessary for restocking such areas with desirable species.

Brush-Control Methods

During the first three years of this study six brush-control measures were tested. These included bulldozing, basal spraying, cupping and poisoning, frilling and poisoning, combination basal spraying and frilling, and cutting. These treatments are described briefly.

For bulldozing woody growth from future planting areas an International TD-9 "dozer" was found satisfactory to uproot brush and saplings. The bulldozer and operator were supplied by the Soil Conservation Service at the rate of \$8.00 per hour. The blade of the bulldozer was set at ground level. In this position a minimum amount of litter and top soil is disturbed, and yet the blade cut sufficiently deep to uproot and dislodge even the smallest trees and brush. Uprooted brush can be left in piles scattered throughout the area, or it can be stacked in windrows along the sides. Brush piles within the planting area should be burned, as they cover a considerable surface area which could otherwise

be utilized for tree seedlings. If the brush is pushed to the sides of the area, it leaves the major portion of the site clear, and the wind-blown brush can be left to rot.

In basal spraying or bark spraying the tree is not cut. The bark at the base of the tree is completely saturated with poison solution to a height of $1\frac{1}{2}$ feet. Spray is applied until the bark can absorb no more and any additional solution merely runs off. All herbicides are most effective when applied in the spring immediately after the foliage develops, and become progressively less effective when applied later in the season. A 5 per cent solution of 2,4,5-T (low volatile ester of 2,4,5-chlorophenoxyacetic acid) in a diesel fuel solvent has been most effective for basal spraying.

In the cupping method notches are chopped at regular intervals around the bole. Cups are approximately 6 inches wide, with 4 inches usually left between adjacent cups. Notches may be cut at a convenient chopping height or at the base of the trunk. Those located nearer the roots afford greater penetration of chemicals into the root system, and higher mortality is obtained. One tablespoonful of Ammate crystals packed into each notch.

A frill consists of a single line of overlapping downward axe cuts made completely around the bole. Frills are customarily made at a convenient chopping height, which in most cases is approximately 4 feet above the ground level. Immediately after the frill is made, the chemical is poured or sprayed into the cut until the exposed wood surface is thoroughly soaked. A 4-pound-per-gallon water solution of Ammate or a 4 per cent solution of 2,4,5-T in a water carrier are both effective herbicides to use in frills.

A combination of basal spraying and frilling is often more economical than either method used alone. Trees larger than 3 inches d.b.h. (diameter breast high) are frilled and treated with a 4 per cent solution of 2,4,5-T in a water carrier. Trees smaller than 3 inches d.b.h. receive a basal spray with a 5 per cent solution of 2,4,5-T in a diesel fuel solvent.

A portable power-driven brush cutter with a circular blade was used to clear brush in some areas. The blade of this cutter was held close to the ground to cut the brush off as low as possible. Trees over 3 inches d.b.h. were cupped and poisoned with Ammate, as the brush cutter was not effective on trees of this size.

Planting

In the spring immediately after hardwood control had been effected each one-acre treatment area was divided into 4 quarter-acre sections. The two sections located on the lower portion of the slope were planted

with white ash (*Fraxinus americana* L.) and yellow-poplar (*Liriodendron tulipifera* L.), respectively. The two sections on the upper slopes were planted with white pine (*Pinus strobus* L.) and shortleaf pine (*Pinus echinata* Mill.),¹ respectively. Six by six-foot spacing was used whenever possible, giving approximately 1,210 seedlings per acre, or 202 seedlings per section. However, this number varied from one treatment area to the next due to interference from standing woody growth and other planting obstacles. Hand planting was used for all areas.

One year after planting, survival counts were made on each area to determine which species had the highest survival following each hardwood control measure. Survival figures for each species and hardwood control costs are to be used to determine the most suitable method of stand conversion.

Discussion

Cost figures and survival figures were analyzed three years after this study was begun. Table 1 gives a summary of these data. The data indicate that any method of stand conversion is expensive. Costs ranged from \$43.57 to \$80.92 per acre, depending on the method employed. When these costs are compared on the basis of cost per inch of circumference of treated hardwood brush, it eliminates variation due to density of stocking on each plot, thus giving a valid basis for comparing relative costs of each method. Of the poisoning methods, combined basal spraying and frilling was least expensive. Bulldozing was more expensive than any other method.

The cost used for the planting stock is an average cost for pine and hardwood based on a six by six-foot spacing, or 1,210 seedlings per acre.

Planting costs varied greatly, depending on the method of hardwood control employed. The bulldozing method and cut-off saw method opened up the site most completely, removing even the smallest woody vegetation. This facilitated hand planting and resulted in the lowest planting costs per acre. Hardwood brush controlled with chemicals remained standing on the planting area. This created a major inconvenience for planting crews, and increased planting costs in all areas where chemical control was used.

When Ammate and the hormone poisons (2,4,5-T and related compounds) are used on woody vegetation, six months to two years are required for the poisons to become effective. For this reason it often is necessary to delay evaluation of poisoning results for a year or more.

¹In 1954 pitch pine (*Pinus rigida* Mill.) was used in place of shortleaf pine due to the difficulty of obtaining shortleaf pine of northern seed source.

TABLE 1. AVERAGE COST FOR CONVERTING BY EACH BRUSH-CONTROL METHOD WITH PERCENTAGE SURVIVAL FIGURES FOR PINE AND HARDWOOD SEEDLINGS. ALL FIGURES ARE ON A PER-ACRE BASIS.

Hardwood Control Method	Costs				Total Circumference (Inches)	Cost of Hardwood Control Per Inch of Circumference	Pine Survival (Percent)	Hardwood Survival (Percent)
	Total Conversion	Hardwood Treatment @ \$.75 per man-hour	Labor for Planting @ \$.75 per man-hour	Planting Stock				
Bulldozing	\$80.92	\$51.35	\$16.25	\$13.32	13,307	0.386¢	85.9	74.0
Basal Spray	72.23	37.91	21.00	13.32	13,629	0.278	71.3	66.4
Frilling	74.07	41.50	29.25	13.32	6,450	0.643	60.7	83.7
Cupping	72.80	33.98	25.50	13.32	3,856	0.881	80.2	83.7
Combination	69.66	36.65	19.69	13.32	17,967	0.204	74.1	59.1
Cut-off Saw	43.57	14.50	15.75	13.32	14,648	0.098	88.3	*

*Figures not yet available. Plots established during the spring of 1956.

obtain reliable data on mortality percentage. This gradual opening of the crown canopy following poisoning is an advantage when hardwood seedlings are planted, as most hardwoods require partial shade during the first few years. However, this cover is usually a detriment to pine due to their high light requirements during the seedling stage.

Bulldozing appears to have given the most effective brush control. Three years after the first area was bulldozed and planted there was no indication that additional hardwood control would be necessary to assure future survival of planting stock. Wherever sassafras and black locust were removed from these areas, numerous root suckers appeared and grew rapidly. However, these scattered sprouts are more aggressive on the portion of the plots planted to hardwoods due to high soil moisture in these areas. The partial shade cast by these sprouts appears to be beneficial to neighboring yellow-poplar and white ash seedlings, resulting in better height growth and increased vigor. On this basis the present plan is to leave these scattered sprouts until it is apparent that their shade is no longer beneficial.

During the first year following bulldozing the site was invaded by a rank growth of herbaceous plants, including goldenrod (*Solidago* spp.), asters (*Aster* spp.), wild lettuce (*Lactuca* spp.), and other similar composites. By the second year a dense grass sod, which had developed over the entire area, crowded out the annuals and completely occupied the site. The shade from these herbaceous plants appears to have had no detrimental effect on the pine and hardwood seedlings, and the roots held the soil in place so that erosion was negligible. The grass sod has offered minor competition to the pines. Pine survival has been high on bulldozed areas, and pine height growth has been superior to that of all other treatment areas. This high growth rate is due to the great amount of light provided following bulldozing and the high light requirements of pine seedlings.

Growth of white ash and yellow-poplar has been severely curtailed because they compete poorly with grass sod. Experiments are now underway to find methods of eliminating grass competition around hardwood seedlings by spot spraying with selective grass herbicides. Hardwood survival on bulldozed areas has been fair, but growth has been poorer than on those plots where some partial shade has been afforded by standing hardwood brush. This is due to the greater amount of light entering the site following bulldozing and the tolerance requirements of hardwood seedlings.

Basal spraying gave effective brush control but proved expensive. Examination of these areas three years after spraying indicated that additional hardwood control would soon be necessary in those areas planted with pine, as occasional sprouts from partially killed brush

ms were offering too much shade for the intolerant pine. Hard-wood seedlings in these areas have grown rapidly and are superior in height growth and vigor to hardwood seedlings on bulldozed areas.

Although annuals had occasionally invaded the forest floor following basal spraying, their density was low compared to the bulldozed areas, and they offered no serious opposition to seedling survival and growth. No grass sod had yet developed due to the partial shade afforded by the standing hardwood brush.

Frilling and poisoning alone proved inadequate as a brush-control method because many stems were too small to treat by frilling, and they began to grow rapidly when the larger stems had been poisoned. Although pine and hardwood survival was high three years after treatment, it was obvious that repeated brush control would soon be necessary if pine and hardwood seedlings were to be brought through successfully.

Cupping with Ammate proved expensive and inadequate for brush control. Trees smaller than 3 inches d.b.h. were not cupped, but were cut off 6 inches above the ground and a tablespoonful of Ammate crystals was placed on each stump. Three years after cupping many stumps were partially alive and gave indication that they would continue to live for many years. Stumps treated with Ammate crystals frequently sprouted and these stems interfered with the development of the planted seedlings. Height growth of hardwood seedlings on these plots has been good, but height growth of pine has been relatively poor.

Basal spraying and frilling together proved most effective of the poisoning methods employed. Frilling gave inexpensive and effective control of the trees larger than 3 inches d.b.h. Basal spraying gave effective control of smaller woody growth and saplings. Hardwoods planted in these areas have made excellent height growth. The poor hardwood survival, as indicated in Table 1, was attributed to the residual effect of herbicide in these areas at the time of planting, as seedlings were planted within 24 hours of poisoning. It is probable that better survival would have been obtained if planting had been delayed for a week after the poison had been applied. Surviving hardwood seedlings have grown well in these areas. Pines had not grown well, due to excessive shade from overhead woody growth.

The brushcutter proved least expensive of all brush-control methods employed. However, these plots were established in the spring of 1956 and there has not been sufficient time to evaluate the effectiveness of this hardwood treatment. Any cutting method will result in sprouting from small stems. There is danger that these sprouts will cause major

competition and necessitate repeated costly cleanings, if the pine and hardwood seedlings are to survive.

Conclusions

Although this study has not been completed, many interesting facts concerning the conversion of brush lands to productive forest types have been revealed. During the first three years of this study 20 half-acre plots were established and planted with pine or hardwood seedlings. Six brush-control methods have been tested.

Due to the high costs of hardwood control and planting determined by this study, it appears economically impractical to convert brush-covered land for general forest management purposes. Stand conversion costs varied from \$43.57 to \$80.92 per acre, depending on the hardwood control method employed. Such costs are considered far in excess of those feasible for plantation establishment. These costs should be borne in mind by foresters acquiring land for planting with pulpwood or sawtimber production as the objective. Recently abandoned fields where brush has not yet completely occupied the site can be planted at a more reasonable cost and will present fewer forest management problems.

When interests other than wood production are concerned, stand conversion costs obtained by this study may be economically justified. Production of Christmas trees and ornamentals usually involves a more rapid turnover of invested funds and may justify higher initial establishment costs. In addition, aesthetic factors may play an important role and warrant large expenditures for replacing brush lands with plantations.

When costs, survival, and growth are considered, bulldozing appears to be the most effective method of preparing brush-covered lands for pine plantings. Although conversion costs of \$80.92 per acre were necessary in this method, re-invasion by hardwood brush and sprouts has been negligible and no additional hardwood control costs appear necessary to assure high seedling survival.

For hardwood plantings a combination of frilling and basal spraying controlled brush and woody growth at a relatively low cost (\$6.66 per acre), and provided a suitable environment for hardwood seedlings to become established and grow rapidly.

As less expensive herbicides become available, and methods of application are improved, it may be possible to reduce stand conversion costs. Only then might it be economically possible to use chemicals for controlling dense brush for stand conversion in general forest management work.