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Stripping of Soil-Applied Hexazinone, Picloram, and Tebuthiuron for Loblolly Pine Site Preparation

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SUMMARY

Herbicides were applied to prepare two upland sites for planting of loblolly pine (*Pinus taeda* L.) after clearcut harvesting: (1) picloram pellets, (2) hexazinone liquid, (3) a slurry of tebuthiuron soluble powder, and (4) following underplanting, a liquid formulation of picloram + 2,4-D was injected into residual hardwoods. The herbicides in treatments 1 through 3 were applied in 4-inch-wide parallel strips spaced 9.8 feet apart in April 1981. On a per-acre basis, the rates of application were 1.8 lb acid equivalent picloram, 1.5 lb active ingredient (a.i.) hexazinone, and 1.5 lb a.i. tebuthiuron. Vegetation on all plots was prescribe burned in August 1981, and the plots were planted in January 1982 with loblolly pine (*Pinus taeda* L.) seedlings. Planting rows were evenly spaced between the chemically treated strips. In treatment 4, all hardwoods 1 inch or greater in diameter at breast height (d.b.h.) were injected near groundline in April 1982.

Although the competing plant cover varied somewhat among the four site preparation treatments, one growing season after the pines were planted, loblolly pine survival, height, and diameter growth were not affected by treatment at either site through five growing seasons. Evidently, stripping soil-active herbicides as a means of preparing loblolly pine planting sites is no better than single-tree injection of the larger hardwoods left after clearcut harvesting.

Keywords: Chemical site preparation, *Pinus taeda* L., single-tree injection, soil-active herbicides, underplanting

INTRODUCTION

Forest regeneration following clearcut harvesting is a major concern in the Southern United States on both private and public lands. On sites where pure pine management is desirable, preparation before planting or seeding often requires the piling, crushing, or killing of residual trees and shrubs and possibly the destruction of debris left from the harvesting operation. These practices can be expensive, and forest managers may seek innovative site preparation methods that will reduce costs but still result in the establishment of fast-growing, well-stocked pine stands.

Herbicides are an alternative to mechanical methods for preparing pine sites for regeneration. They are normally broadcast either as foliar sprays or in pellet formulations. Under certain conditions, injection of individual stems with a herbicide may be the best means of chemically treating the residual vegetation. Chemically treated sites are usually prescribe burned before planting or seeding.

The application of soil-active herbicides in narrow parallel strips is another way to control vegetation. Concentrating the herbicide in a limited volume of soil should control plants with roots growing within these narrow strips of soil. Pine seedlings that were planted or developed from seeds between these strips would not be injured. Conceptually, once the pine root systems grow into these treated strips of soil, the residual concentration of herbicide would be insufficient to harm the regeneration because, over time, herbicides are biologi-

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cally degraded, absorbed by plants, or leached from the root zone. The application of herbicides to narrow parallel strips can be done by hand using granular formulations or by dispensing a liquid concentrate or slurry with backpack equipment. The tract can be any size or shape. Drift is not a concern because dry materials or coarse sprays are used.

To test the concept of using stripping as a means of herbicide site preparation, two clearcut-harvested sites were treated with three soil-active herbicides for comparison to single-tree injection. The objectives were to determine (1) whether strip application was a reasonable method of site preparation for regenerating loblolly pine (*Pinus taeda* L.), (2) whether one herbicide treatment was better than the others, and (3) what the initial effects were of herbicide use on the existing plant community.

STUDY AREAS

Two study areas were selected in central Louisiana that had been clearcut harvested. Site 1 is a Gore very fine sandy loam (Vertic Paleudalfs, fine, mixed, thermic) with a 1- to 5-percent slope. It is moderately well drained with a clayey subsoil and has low natural fertility, medium runoff, and slow water movement through the soil (Kerr and others 1980). Severe drought stress can develop during summer, but this soil can become waterlogged for extended periods during winter. It is a moderately productive soil with a site index (base age 50 years) of 75 feet for loblolly pine.

Site 2 is a complex of soils, but the major soils are Beauregard silt loam (Plinthaquic Paleudults, fine-silty, siliceous, thermic) and Ruston fine sandy loam (Typic Paleudults, fine-loamy, siliceous, thermic) with a 1- to 3-percent slope. The Beauregard silt loam is moderately well drained; it has low natural fertility, slow runoff, and slow water movement through the soil (Kerr and others 1980). Severe drought stress can develop during summer, but this soil can become waterlogged for extended periods during winter. It is a highly productive soil with a site index (base age 50 years) of 90 feet for loblolly pine.

The Ruston sandy loam is well drained; it has low natural fertility, medium runoff, and moderate water movement through the soil. Roots penetrate easily. A seasonally high water table is below 6 feet. It is a highly productive soil with a site index (base age 50 years) of 90 feet for loblolly pine.

After clearcut harvesting, both sites were left fallow for at least a year. At Site 1, the common residual plants were sweetgum, *Liquidambar styraciflua* L.; blackgum, *Nyssa sylvatica* Marsh.; post oak, *Quercus stellata* Wangenh.; red maple, *Acer rubrum* L.; flowering dogwood, *Cornus florida* L.; American beautyberry, *Callicarpa americana* L.; southern bayberry, *Myrica cerifera* L.; shining sumac, *Rhus copallina* L.; yaupon, *Ilex vomitoria* Ait.; and several hawthorns, *Crataegus* spp.; blackberries, *Rubus* spp.; and blueberries, *Vaccinium* spp. At Site 2, the common residual plants were post oak; black cherry, *Prunus serotina* Ehrh.; sweetgum; red maple; blackjack oak, *Q. marilandica* Muenchh.; southern red oak, *Q. falcata* Michx. var. *falcata*; American holly, *I. opaca* Ait.; mockernut hickory, *Carya tomentosa* (Poir.) Nutt.; flowering dogwood; shining sumac; southern bayberry; and several hawthorns, blackberries, and blueberries.

METHODS

Experimental Design and Treatment

At each site, four blocks of four site preparation treatments each were established in a randomized complete block design; the blocks served as replicates. Blocking was based on the species richness and abundance of brush species (small trees and shrubs less than 1 inch in diameter at breast height [d.b.h.]) at 4.5 feet above groundline and on slope.

Each of the 32 plots (2 sites by 4 blocks by 4 treatments) measured 117.6 by 72.6 feet (0.196 acre). Because concentrated strips of herbicides would be applied, the plots were wider than normal for the planting scheme to provide sufficient buffer between the outside herbicide strip and the plot edge. Also, plots were separated from each other by 16.4-foot buffers.

An inch and a half of rain fell on March 27 and 28, 1981, so the soil was well watered several days before

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The products used for soil application were Velpar® L (hexazinone [3-cyclohexyl-6-(dimethylamino)-1-methyl-1,3,5-triazine-2,4(1H,3H)-dione]), Tordon® 10K (picloram [4-amino-3,5,6-trichloro-2-pyridinecarboxylic acid]), and Spike® 80W (tebuthiuron [N-[5-(1,1-dimethylethyl)-1,3,4-thiadiazol-2-yl]-N,N′-dimethylurea]). Tordon® 101 Mixture (picloram + 2,4-D [2,4-dichlorophenoxy]acetic acid]) was used for tree injection. Use of trade names is solely for the benefit of the reader, and discussion of herbicides in this paper does not constitute recommendation of their use or imply that the uses discussed here are registered. If herbicides are handled, applied, or disposed of improperly, there is potential for hazards to the applicators, off-site plants, and the environment. Herbicides should be used only when needed and should be handled safely. Follow directions and heed all precautions on the container label.

CAUTION: Pesticides can be injurious to humans, domestic animals, desirable plants, and fish or other wildlife if they are not handled or applied properly. Use all pesticides selectively and carefully. Follow recommended practices for the disposal of surplus pesticides and pesticide containers.

the soil-active herbicides were applied at both sites. On April 1 and 2, 1981, the herbicides were singly applied in parallel strips to treatments 1 through 3. The three herbicide formulations used were either picloram pellets, hexazinone liquid, or a slurry of tebuthiuron wettable powder. The herbicide was concentrated in strips 4 inches wide and 72.6 feet long spaced 9.8 feet apart. Within these strips, rates of application were 54 lb acid equivalent (a.e.) picloram, 46 lb active ingredient (a.i.) hexazinone, or 46 lb a.i. tebuthiuron per acre. On a per-acre basis, the application rates were 1.8 lb a.e. picloram, 1.5 lb a.i. hexazinone, or 1.5 lb a.i. tebuthiuron per acre.

All plots were prescribe burned in August 1981. At Site 1, most of the large hardwoods (1 inch or greater in d.b.h.) were killed back to groundline. Only half of the large hardwoods at Site 2 were killed back.

All plots were planted in January 1982 with 1-0 bareroot loblolly pine seedlings. Each plot contained 11 rows of 11 planted pines each. The rows were spaced 9.8 feet apart, and the trees were spaced 6.6 feet apart within rows. The planting rows were evenly spaced between the chemically treated strips, so none of the seedlings were planted in the strips.

For comparison purposes, an underplant-inject treatment was installed in April 1982 as the fourth site preparation treatment. On these plots, all hardwoods 1 inch or greater in d.b.h. were injected near groundline with a picloram + 2,4-D formulation.

Measurements and Data Analysis

The center 49 planted loblolly pines comprised each measurement plot (0.073 acre). Within each measurement plot, four 9.8- by 6.6-foot subplots were systematically located. These subplots were used to collect data on brush, vine, and herbaceous vegetation. Brush species were identified, rootstocks counted, and heights measured one growing season after the pines were planted. The identity and coverage of vines and herbaceous plants was determined. Coverage was defined as the percent of area the herbaceous plants and vines would shade if the sun were directly overhead.

Within each 0.073-acre measurement plot, large hardwoods (1 inch or greater in d. b. h.) were identified, and total height and d.b.h. measured one growing season after the pines were planted. Planted loblolly pines were counted and heights measured through five growing seasons. Pine d.b.h. was measured after five growing seasons.

For each site, percentage of herbaceous plant and vine cover; number of rootstocks per acre; height of brush; and percentage of survival, height, and d.b.h. of planted loblolly pines were analyzed by analyses of variance (Probability >F-value = 0.05). Duncan's Multiple Range tests were used to determine means separation if necessary.

Statistical analysis of the large hardwood data was not practical because the large hardwoods were scattered at both sites and because plot layout did not provide for a representative sample on each plot. General comments about the species richness and abundance of large hardwoods were made, however.

RESULTS AND DISCUSSION

Competing Vegetation

One growing season after the pines were planted, herbaceous vegetation covered 63 and 69 percent of the plot surface at Sites 1 and 2, respectively (table 1). There were no significant differences among site preparation treatments at either site.

Table 1.—*Percentages of herbaceous plant and vine cover and the number and height of competing trees and shrubs less than 1 inch in d.b.h. one growing season after the pines were planted**

Site and treatment	Herbaceous cover	Vine cover	Rootstocks/acre		Tree and shrub height
			Tree	Shrubs	
	Percent		*Count*		*Feet*
Site 1					
Underplant-inject	59a	1a	1,175a	6,325a	1.8a
Picloram	56a	1a	1,175a	4,050a	1.1b
Hexazinone	71a	1a	1,075a	5,100a	1.9a
Tebuthiuron	65a	2a	975a	3,500a	1.2b
Average	63	1	1,100	4,744	1.5
Site 2					
Underplant-inject	62a	3a	3,125a	6,400a	1.7a
Picloram	71a	1a	1,175a	4,350a	0.9b
Hexazinone	67a	1a	3,075a	6,325a	1.5a
Tebuthiuron	77a	1a	2,350a	6,200a	1.4a
Average	69	1	2,431	5,819	1.4

*For each site, columnar means followed by the same letter are not significantly different based on Duncan's Multiple Range Tests (Probability>F-value=0.05).

Table 2.—*Number, d.b.h., and height of hardwoods 1 inch or greater in d.b.h. one growing season after the pines were planted at Site 1*

Variable and species	Treatment			
	Underplant-inject	Picloram	Hexazinone	Tebuthiuron
	Stems/acre			
Number				
Post oak	3	65	3	0
Mockernut hickory	0	3	0	0
Sweetgum	0	14	3	7
Tree sparkleberry	0	0	3	0
Southern red oak	0	0	0	3
Total/acre	3	82	9	10
	Inches			
D.b.h.				
Post oak	6.5	5.1	3.3	0.0
Mockernut hickory	.0	2.7	.0	.0
Sweetgum	.0	2.5	1.7	6.5
Tree sparkleberry	.0	.0	3.1	.0
Southern red oak	.0	.0	.0	6.8
Weighted mean	6.5	4.6	2.7	6.6
	Feet			
Height				
Post oak	43.0	31.5	21.7	.0
Mockernut hickory	.0	19.4	.0	.0
Sweetgum	.0	19.7	12.5	17.7
Tree sparkleberry	.0	.0	10.8	.0
Southern red oak	.0	.0	.0	38.1
Weighted mean	43.0	29.0	15.0	23.8

At Site 1, typical herbaceous plants were panicums, *Panicum* spp. and *Dichanthelium* spp.; bluestems, *Andropogon* spp. and *Schizachyrium* spp.; common carpetgrass, *Axonopus affinis* Chase; paspalums, *Paspalum* spp.; hairy crabgrass, *Digitaria sanguinalis* (L.) Scop; three-awns, *Aristida* spp.; pinehill beak-rush, *Rhynchospora globularis* (Chapm.) Small; sunflowers, *Helianthus* spp.; asters, *Aster* spp.; eupatoriums, *Eupatorium* spp.; fireweed, *Erechitites hieracifolia* (L.) Raf.; daisy fleabane, *Erigeron strigosus* Muhl. ex Willd. var. *beyrichii* (Fisch. & Mey.) T.&G. ex Gray; goldenrods, *Solidago* spp.; mountainmints, *Pycnanthemum* spp.; mecardonia, *Mecardonia accuminata* (Walt.) Small; and hypericums, *Hypericum* spp. At Site 2, typical herbaceous plants were panicums; bluestems; common carpetgrass; paspalums; uniola grasses, *Chasmanthium* spp.; pinehill beak-rush; sunflowers; eupatoriums; fireweed; daisy fleabane; mountainmints; mecardonia; Maryland meadowbeauty, *Rhexia mariana* L.; and southern bracken, *Pteridium aquilinum* (L.) Kuhn var. *pseudocaudatum* (Clute) Heller.

Vines covered 1 percent of the plot surface at both study sites, and there were no significant differences among treatments (table 1). At both sites, typical species were Carolina jessamine, *Gelsemium sempervirens* (L.) Ait. f.; poison ivy, *Toxicodendron radicans* (L.) Kuntze; muscadine grape, *Vitis rotundifolia* Michx.; greenbrier, *Smilax* spp.; Virginia creeper, *Parthenocissus quinquefolia* (L.) Planch; and Alabama supplejack, *Berchemia scandens* (Hill) K. Koch. Cross-vine, *Bignonia capreolata* L., was also typical at Site 1.

The number of small hardwood tree rootstocks averaged 1,100 and 2,431 per acre at Sites 1 and 2, respectively, and shrub rootstocks averaged 4,744 and 5,819 per acre at Sites 1 and 2, respectively (table 1). There were no significant treatment effects on the number of small trees and shrubs per acre at either site.

At both sites, typical brush species were sweetgum, American beautyberry, shining sumac, southern bayberry, and several blackberries. Southern red oak; black cherry; St. -Andrews-Cross, *Hypericum hypericoides* (L.) Crantz; and several blueberries were also typical at Site 2.

At Site 1, average height of brush was significantly less on the picloram and tebuthiuron treatments than on the underplant-inject and hexazinone treatments (table 1). At Site 2, the brush was shorter on the picloram treatment than on the other three treatments.

At Site 1, the picloram treatment left more large hardwoods per acre than the other treatments (table 2).

Table 3.—*Number, d.b.h., and height of hardwoods 1 inch or greater in d.b.h. one growing season after the pines were planted at Site 2*

Variable and species	Treatment			
	Underplant-inject	Picloram	Hexazinone	Tebuthiuron
	Stems/acre			
Number				
Sweetgum	11	0	0	3
Blackgum	10	3	7	3
Mockernut hickory	7	3	10	0
Southern red oak	0	17	3	3
Black cherry	0	0	3	0
Post oak	0	0	14	0
Total/acre	28	23	37	9
	Inches			
D.b.h.				
Sweetgum	8.0	0.0	0.0	4.8
Blackgum	4.1	2.5	4.6	1.4
Mockernut hickory	4.2	9.7	5.7	.0
Southern red oak	.0	11.0	3.7	11.2
Black cherry	.0	.0	5.9	.0
Post oak	.0	.0	8.2	.0
Weighted mean	5.7	9.7	6.3	5.8
	Feet			
Height				
Sweetgum	42.7	.0	.0	28.9
Blackgum	24.6	5.9	23.3	5.3
Mockernut hickory	26.5	45.0	19.0	.0
Southern red oak	.0	45.3	29.9	56.1
Black cherry	.0	.0	46.9	.0
Post oak	.0	.0	45.0	.0
Weighted mean	32.2	40.1	32.8	30.1

However, as stated previously, valid statistical comparisons could not be made. At Site 2, the number of large hardwoods per acre was similar among treatments (table 3).

Loblolly Pine

After planting, a winter/spring drought occurred at both sites. At Site 1, the January 1982 rainfall deficit was 2.6 inches below a 31-year average for the location, and by July, the rainfall deficit was 9.7 inches below this average. At Site 2, the January 1982 rainfall deficit was 1.8 inches below a 39-year average for the location, and by July, the rainfall deficit was 5.9 inches below this average. Rainfall remained well below normal for the year at both sites until above-normal rainfall occurred in November and December. The drought probably had a negative effect on the newly planted seedlings because survival averaged 55 and 73 percent at Sites 1 and 2, respectively, with no significant treatment effects on pine survival one growing season after the pines were planted (table 4).

Table 4.—*Loblolly pine survival one and five growing seasons after pines were planted and pine height and d.b.h. after 5 years**

Site and treatment	Survival		5th year	
	1st year	5th year	Height	D.b.h.
	Percent		*Feet*	*Inches*
Site 1				
Underplant-inject	50a	47a	12.4a	1.9a
Picloram	58a	54a	11.4a	1.6a
Hexazinone	54a	52a	10.9a	1.6a
Tebuthiuron	60a	55a	11.8a	1.8a
Average	55	52	11.6	1.7
Site 2				
Underplant-inject	70a	60a	11.2a	1.4a
Picloram	77a	71a	10.7a	1.3a
Hexazinone	79a	69a	11.6a	1.4a
Tebuthiuron	68a	62a	11.6a	1.5a
Average	73	65	11.3	1.4

*For each site, columnar means followed by the same letter are not significantly different based on Duncan's Multiple Range Tests (Probability>F-value=0.05).

Loblolly pine survival remained relatively stable after the first year, and survival after five growing seasons averaged 52 percent at Site 1 and 65 percent at Site 2 (table 4). Five-year-old loblolly pine height averaged 11.6 and 11.3 feet, and d.b.h. averaged 1.7 and 1.4 inches at Sites 1 and 2, respectively. There were no significant treatment effects on 5-year survival, height, or d.b.h. at either site.

Hardwood competition seemed sufficient at both sites to influence seedling loblolly pine development (Haywood and Toliver 1989, Tiarks and Haywood 1986). However, pine height growth was comparable to other 5-year-old planted loblolly pine stands growing on moderately to highly productive silt loam soils in central Louisiana where established grasses rather than hardwoods were the primary competitors (Haywood and Toliver 1989). In Haywood and Toliver's (1989) study, delays in establishment of pine regeneration led to a reduction in sapling pine growth within mixed pine-hardwood stands. This result was apparently avoided in the present study because the established pine regeneration had been planted in a timely manner—10 months after the soil-active herbicides were stripped and 5 months after the prescribed burn.

CONCLUSIONS

One growing season after loblolly pines were planted, both sites supported high populations of herbaceous, vine, and woody competitors regardless of site preparation treatment. Although there were some differences in competing plant populations among treatments, loblolly pine survival, height, and diameter growth were not affected by site preparation method through five growing seasons at either site. Evidently, stripping soil-active herbicides as a means of preparing pine planting sites is no better than single-tree injection of the larger residual hardwoods left after clearcut harvesting. However, all four treatments were successful in establishing pine regeneration. The most detrimental factor was the drought during the first growing season, which most likely resulted in the relatively poor seedling survival on all treatments.

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