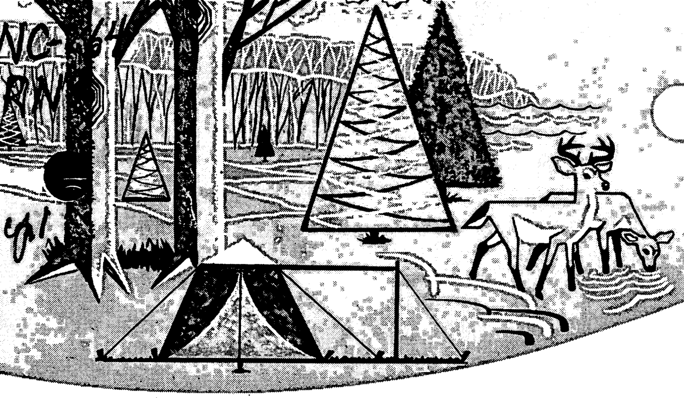

U. S. FOREST SERVICE

RESEARCH NOTE NC-64

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FUEL EVALUATION FOR A MISSOURI PINE PLANTATION RELEASED BY AERIAL SPRAYING

ABSTRACT. — Fuel changes resulting from aerial herbicide application to control hardwoods competing with 13-year-old underplanted pine in Missouri are described. Fuel hazard is generally maximum about the fifth year after treatment and is affected by relative pine and hardwood densities.

Stands of low-grade, undesirable hardwoods are being converted to shortleaf pine on many acres of Missouri forest land. Hardwoods are controlled largely by broadcast applications of herbicides either for planting site preparation or in later release of the pine. The increased fuel hazard during the following 10 years or so is of concern to those responsible for forest fire control. In 1955 we established a study to learn how forest fuels change during this period.

The Study

The 40-acre study area, in Dent County, Missouri, was planted to shortleaf pine in 1942. Between that year and 1955 all hardwoods merchantable as sawtimber were cut and many culls were girdled. Cutting and the absence of fire allowed oak sprouts to develop. In June 1955 five treatment blocks of about 8 acres each were established. In four of the blocks, the pines were released from the developing sprouts and from scattered larger, unmerchantable trees with an aerial application of herbicides. One block was left untreated. Two of the treated blocks were resprayed in June 1957.

Fuel weight data were collected between January and March 1960 and again in 1963 on a transect through each of the five blocks:

1. Forest floor weights (litter, all duff that could be collected with a minimum of mineral soil, and decomposing wood less than ½-inch thick that could be crushed between fingers) were based on 20 subsamples per transect. Each subsample consisted of material collected from five spots, each 3.8 inches in diameter.
2. Dead fallen wood up to 6.0 inches in diameter was collected from 100 locations per transect, each location containing 18 square feet. Wood thicker than 6 inches was excluded because it was scarce and because its effect on fire behavior would be limited and localized. Dead woody fuel less than 1.5 inches in diameter was classified on the basis of the height above ground of the major portion (by weight) (fig. 1).
3. Grass and herbaceous material was clipped on 25 circular subplots per transect, each subplot containing 9.6 square feet.
4. The weights of pine crown fuels were estimated on the basis of results from a previous study.[1]

All weights were computed on an ovendry, tons-per-acre basis.

Pine basal area was estimated in 1963 with a wedge prism on alternate sampling points from which dead fallen wood was collected.

[1] *Crosby, John S. and Robert M. Loomis. How thinnings affect fuel weights in shortleaf pine stands in southeast Missouri. J. Forest. 65(12): 901-902. 1967.*

Figure 1. — These dead woody fuels less than 1.5 inches in diameter were classified as higher than 12 inches above the forest floor. (F-518181)

Results and Discussion

On some areas within each treatment block, the pine had been relatively free from competition and grew well so that by the time of treatment the stands were nearly closed. On other areas, pines[1] were few and small and hardwoods were numerous. Since treatment killed only hardwoods, important fuel differences occurred between areas poorly stocked and well stocked with pine (fig. 2). Fuel changes also differed between treated and untreated areas. But the differences occurring between the blocks sprayed once and those sprayed twice were small and are ignored in the following discussion.

Eight years after treatment, pine basal area (a single indicator representing relative pine and hardwood densities) averaged 30 square feet per acre for the untreated areas and 75 square feet for all treated areas. Considering treated areas only, the pine basal area was 30 square feet in stands poorly stocked with pine and 125 square feet for those well stocked with pine (table 1).

The herbicide treatment caused a greater difference in weight of dead fallen woody fuels than for any other fuel fraction except living pine crowns. The untreated stand averaged 0.8 ton per acre, whereas the treated areas averaged 3.7 tons per acre (table 1). Weights were consistently less for all wood-size classes on the untreated area. The difference between the well stocked and poorly stocked pine stands in the treated area was even greater — 4 tons per acre.

The average forest floor weights for the treated (5.1 tons per acre) and untreated (5.0 tons) areas were about the same (fig. 3). However, forest floor weights within the treated area varied with the degree of pine stocking. The litter and duff weight for the dense pine was 5.6 tons, about 2 tons per acre more than for the poorly stocked pine.

Figure 2. — Two areas 5 years after treatment. (*Left*) On this area, which was poorly stocked with pine and heavily stocked with hardwoods, most small hardwoods are already down. The primary fuels are a poorly developed forest floor, including grass and herbaceous materials, and hazardously arranged dead fallen woody fuel. (*Right*) This area was well stocked with pine and poorly stocked with hardwoods. The primary fuels are the well developed forest floor and a small amount of dead and down woody fuel. (F-518182-518183)

Table 1.—*Average fuel weights 5 to 8 years after herbicide treatment of competing hardwoods in a 13-year-old pine plantation, Dent County, Missouri (In tons per acre)*

Kind of fuel	Untreated area (30 BA[1/])	Treated area: Average (75 BA)	Treated area: Pine poorly stocked (30 BA)	Treated area: Pine well stocked (125 BA)
Herbaceous grasses and herbs	0.0	0.1	0.1	0.1
Forest floor:				
Litter	2.1	2.1	1.4	2.2
Duff	2.9	3.0	2.2	3.4
Total	5.0	5.1	3.6	5.6
Dead fallen wood, diameter in inches:				
0.0-0.5	.2	.8	1.8	.7
0.6-1.5	.3	1.2	2.4	.9
1.6-3.0	.1	1.2	1.8	.8
3.1-6.0	.2	.5	.5	.1
Total	.8	3.7	6.5	2.5
Pine crowns 8 years after treatment:				
Foliage	.7	1.5	.7	2.1
Branch wood	2.7	5.3	2.7	6.0
Total	3.4	6.8	3.4	8.1
Combinations:				
Grasses, herbs, & litter	2.1	2.2	1.5	2.3
Grasses, herbs, litter, duff, wood 0.0-3.0 inches	5.6	8.4	9.7	8.1
Grasses, herbs, litter, duff, wood 0.0-6.0 inches pine foliage	6.5	10.4	10.9	10.3
Grasses, herbs, litter, duff, wood 0.0-6.0 inches, pine foliage & branch wood	9.2	15.7	13.6	16.3

[1/] Pine basal area (BA) in square feet at age 21, 8 years after treatment.

Grasses and herbaceous fuels were patchy and most prevalent on the poorly stocked, treated pine areas, where much of the poorly developed forest floor consisted of the unattached dead grass and herbs. Ehrenreich[2] reported that these fuels amounted to 1,200 pounds per acre 1 year after treatment, 300 pounds 2 years after treatment, and 200 pounds 3 years after treatment. The amount and duration of grasses and herbs probably vary among different areas. The amount of this production is inversely related to tree crown density.

[2] *Ehrenreich, John H. Releasing understory pine increased herbage production. Central States Forest Experiment Station, Sta. Note 139, 2 p. 1959.*

The living pine crown weight showed the desirable release response: 8 years after treatment there was about twice as much foliage and branch wood on treated (6.8 tons per acre) as on untreated (3.4 tons) areas. The poorly stocked treated areas had the same crown weight as the untreated area, but there were 8.1 tons per acre on the well stocked, treated areas.

Figure 3.—The untreated area had a relatively uniform fuel situation, the primary fuel being the forest floor. (F-518184)

Although woody fuel weights did not change appreciably between 1960 and 1963, the vertical arrangement of the fuel was different. Five years after treatment, most of the fallen woody fuel less than 1.5 inches in diameter was still above the forest floor on about 90 percent of the treated area. By the eighth year, most of this fuel was on or within the forest floor on more than half the treated area, and on all the untreated area. Arrangement was probably most hazardous on the treated area about 5 years after treatment, with total hazard decreasing from then on, although 10 years after treatment the treated area still had an obviously greater hazard in both weight and arrangement than the untreated area.

Another study showed that 2 years after herbicide treatment of hardwoods, a significant amount of small branch wood was falling; by the seventh year, almost all branch wood and small saplings as well as most small pole-sized trees were down.[3] Some

[3] *Loomis, Robert M., and John S. Crosby. The breakup of dead hardwood trees and the fuel hazard following timber stand improvement operations in southeast Missouri Ozarks. (Manuscript in preparation.)*

large poles remained as standing snags after 10 years, and probably some sawtimber-sized trees will still be standing as snags after 15 years. Maximum hazard for most treated areas was considered to be from about the third to seventh year after treatment.

In the current study the amount of fuel increase on the treated area was enough to materially influence fire intensity, but the arrangement of the fuel and its exposure would cause most concern. Within the untreated area, the annual fall of branch wood is light and the wood usually incorporates into the forest floor in a short time. However, on treated areas the much larger amount of wood that falls is initially arranged in depths up to 3 or 4 feet. These fuels are especially hazardous because: they are exposed to rapid drying, a high percentage is likely to be available fuel, they ignite easily from fire in the forest floor, they may contribute to an intense fire and provide burning embers that are carried upward by convection to cause spotting ahead, and they may interfere with movement of men and machines engaged in suppression.

The effect of fuel weights on fire intensity and resistance to control and the subsequent effects on living vegetation depend upon both fuel composition and burning conditions. Byram[4] states that fire intensity varies with the amount of available fuel, the rate of spread, and the heat capacity of the fuel. Because both the amount of available fuel and the rate of spread increase as fuels become drier, the potential fire intensity on the study area will vary with burning conditions.

As drying progresses after a complete wetting, the more exposed and finest fuels dry to flammability first. Moreover, as the quantity of flammable fuels increases these fuels when burned can dry additional fuels so they will also burn. Although a precise estimate of available fuel increments as drying progresses is not possible, some steps in fuel addition can be postulated from this study in the fuels 5 to 8 years after treatment.

Under minimum conditions for burning, only the litter, grasses, and herbs would likely be consumed. For the four area situations, the fuel weights would not be very different, ranging from about 1.5 to 2.3 tons per acre (table 1).

[4] *Byram, George M. Forest fire behavior.* In *Forest fire: control and use. By Kenneth P. Davis, 584 p., illus. New York, Toronto [etc.]: McGraw-Hill Book Co.*

As drying proceeds, it is likely that the forest floor duff and fallen woody fuels up to about 3 inches in size would become available, increasing available fuel to between 5.6 and 9.7 tons per acre (table 1). The lowest amount was on the untreated area and greatest on poorly stocked pine areas.

If a fire was hot enough to burn the pine crowns, the foliage could add about 0.7 to 2.1 tons per acre to the available fuel on the areas studied. With more severe conditions, branch wood could also be burned. Under the most severe conditions, the probable available fuel could amount to approximately 9.2 to 16.3 tons per acre. (Although some live hardwood crown branch wood and some standing dead woody fuels might also be burned, these were not included in weight estimates.)

With the more common burning conditions, the poorly stocked pine area would have the most available fuel. But, with very severe conditions permitting crown fire, the well stocked pine area has the most available fuel, the greatest fire intensity potential, and the possibility for the most damage.

Conclusions

An increased fuel hazard due to broadcast herbicide treatment of hardwoods is primarily controlled in kind, amount, and duration by number, size, and species of dead and of living trees per unit area. A typical sequence of events can be expected following treatment: Site exposure increases almost immediately, with the opened crown canopy allowing faster drying by sun and wind. Grass and herbaceous growth may increase greatly 1 year after treatment; but this production may drop quickly to a small amount, depending upon rate of increase of tree crown cover. Most branch wood, saplings, and small poles fall between 2 and 7 years after treatment. Maximum hazard will probably occur about the fifth year. A hazardous vertical fuel arrangement of fallen wood less than 1.5 inches in diameter, present by the fifth year, is much less critical by the eighth year. Some large poles may remain standing as snags even after 10 years and some sawtimber-sized trees will probably be standing as snags after 15 years.

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