

441. 414. 12

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1966

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Herbicides for Site Preparation

*... broadcast spray by mist blower tested
against understory in Hawaii rain forest*

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ABSTRACT: Two studies started in 1964 tested control of dense understory vegetation in Hawaii rain forests with herbicides applied by a large turbine blower spraying from widely spaced bulldozer lines. Brushkiller and Tordon 101 were effective on shrubs. Results on treefern were poor, but encouraging enough to merit additional study.

A better method of reducing understory vegetation would help efforts to improve the forest resources of Hawaii. Much recent reforestation, mainly by the Hawaii Division of Forestry, is in rain forests on the Island of Hawaii. These forests have two distinct canopy levels (fig.

1). The open overstory is dominated by ohia (Metrosideros collina (Forst.) Gray). The dense understory--treefern (Cibotium spp.) and scattered shrubs--often shades at least 90 percent of the ground. Beneath both stories, the forest floor is essentially bare; ground cover usually exists only in the forest openings.

To replace slow growing, poor quality, native forests with fast growing, exotic hardwoods of high quality, site preparation seeks to reduce both the overstory and understory vegetation. The understory, however, is the major barrier to successful reforestation.

A common procedure in present site preparation work is first to harvest treeferns of commercial size and then to knockdown and crush the ohia and understory vegetation with a heavy bulldozer. This costs about \$50 per acre.¹ Bulldozers disturb and compact the wet soils. Effective herbicide applications would eliminate problems of soil disturbance and possibly reduce total costs. Broadcast foliar applications would be particularly efficient on rocky ground and in areas of high plant density. Survival and growth of planted trees require only temporary suppression of most of the competing plants. Neither kill nor knockdown of all plants would be required.

Small tests by chemical companies, ranchers, the Bishop Estate, and the University of Hawaii have indicated several herbicides that are

¹Personal correspondence with Russell K. LeBarron, Hawaii Division of Forestry, Honolulu, Hawaii, March 14, 1966.

U.S. Forest Service research in Hawaii is conducted in cooperation with the Division of Forestry, Hawaii Department of Land and Natural Resources.

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promising, although adequate control of tree fern was not achieved. Generally those herbicides containing 2, 4-D and 2, 4, 5-T were the most successful. Bishop Estate tests in 1963 showed limited chemical coverage could be obtained from small backpack mistblowers.² Use of a larger blower and spraying from widely spaced bulldozer lines appears to be a more promising application method.

Locations and Treatments

Herbicide sprays were tested in 1964 at two locations on the Island of Hawaii: (1) near Kulani Honor Camp, in cooperation with the Hawaii Department of Social Services; and (2) near Holualoa in the Kahaluu Forest Reserve, in cooperation with the Bernice P. Bishop Estate.

Both sites are typical of areas being reforested in the rain forest type: dense understory canopy of treefern and occasional woody shrubs beneath an overstory of scattered ohia trees. Elevation of the Kulani area is 5,000 feet, with an annual precipitation averaging 97 inches. The elevation of the Holualoa study site is 2,500 feet. Annual precipitation averages 95 inches.

Three herbicides--a 1:1 brushkiller mixture of butoxy ethanol esters of 2, 4-D and 2, 4, 5-T, pentachlorophenol, and Def, a defoliant--were tested at Kulani. Two others--Tordon 101 and Diquat--were added at Holualoa. Each herbicide was tested at three rates (table 1).

The brushkiller mixture was applied in a water-oil emulsion with diesel oil at 3 percent of the total volume. The pentachlorophenol mixture contained aromatic oil and was also applied in the form of a water-oil emulsion. Water was the carrier for the other herbicides. A surfactant, Tergitol, was mixed with the Diquat at 0.1 percent of total spray volume. An emulsifier, Stephen Agent, was used with the Def and pentachlorophenol.

A trailer-mounted Buffalo Turbine Blower for spraying understory vegetation was used at both locations. It was modified by using a flexible 12-inch diameter tube to raise the discharge level of the air stream to a point 12 feet above the ground (fig. 2). Chemical mixtures were discharged into the air stream at this point through four Tee Jet No. 80015 spray nozzles.

One-half acre plots were located on both sides of bulldozed lines or forest trails. Each plot was 50 feet deep and 435 feet long. The sprayer was calibrated for application, over a 50-foot swath, at a volume of 22 gallons per acre at Kulani and 32 gallons per acre at Holualoa. Each treatment was replicated twice at each location.

Results

The plots were evaluated at two-month intervals for one year following treatment. Observations were made on 15 plants of each major understory species in a spray plot. If fewer than 15 plants of a species were present, all plants were used as the population sample. Sprouting was recorded whenever it was observed.

²Carlson, Norman E. Unpublished notes on file at Bishop Estate, Kealahou, Hawaii, 1963.



Figure 1.--A typical Hawaii rain forest consists of two separate stories. Scattered ohia trees dominate the over-story. Treefern and shrubs form a dense understory.

Figure 2.--The herbicides were applied with a large turbine blower from a forest trail or bulldozed line. Photo by Norman K. Carlson, Bernice P. Bishop Estate.



Table 1.--Common and chemical names and rates of herbicides used,
island of Hawaii, 1964

Common name	Chemical name	Rates per acre
Brushkiller	2,4-dichlorophenoxyacetic acid and 2,4,5-trichlorophenoxyacetic acid. (50:50 mixture)	2,4, and 8 pounds (acid equivalent)
Tordon 101 mixture	4-amino-3,5,6-trichloropicolinic acid and 2,4-dichlorophenoxyacetic acid	1/2, 1, and 2 gallons
Diquat	1:1 'ethyline-2:2 'dipyridilium dibromide	1/2, 1, and 2 pints
Penta weed-killer	Pentachlorophenol and aromatic oil	1/2, 1, and 2 gallons
Def defoliant	S,S,S, tributyl phosphorotri-thioite	1, 2, and 4 pints

Table 2.--Effect of broadcast chemical sprays on treefern, after 1 year, island of Hawaii, 1964. (Basis, 495 plants)

Herbicide	Rate per acre	Kulani ¹		Holualoa		Average	
		Height	Degree of control ²	Height	Degree of control	Height	Degree of control
		Feet		Feet		Feet	
Brushkiller	2 lbs.	10	1.0	9	1.6	10	1.3
	4 lbs.	10	1.5	9	1.9	10	1.7
	8 lbs.	10	1.5	10	2.1	10	1.8
Tordon 101	1/2 gal.	--	--	10	1.4	10	1.4
	1 gal.	--	--	10	1.8	10	1.8
	2 gal.	--	--	10	1.8	10	1.8
Diquat	1/2 pt.	--	--	11	1.2	11	1.2
	1 pt.	--	--	11	1.4	11	1.4
	2 pt.	--	--	9	1.7	9	1.7
Penta weed-killer	1/2 gal.	8	1.0	11	1.3	10	1.2
	1 gal.	10	1.0	10	1.4	10	1.2
	2 gal.	10	1.2	10	1.4	10	1.3
Def	1 pt.	10	1.0	12	1.0	11	1.0
	2 pt.	11	1.0	10	1.0	10	1.0
	4 pt.	8	1.0	11	1.0	10	1.0

¹Tordon 101 and diquat were not tested at Kulani.

²Control evaluated on the basis of a rating index as follows:

- 1 = no apparent control
- 2 = slight control
- 3 = moderate control
- 4 = good control
- 5 = complete control (plant killed).

Treefern

Treefern, the dominant understory vegetation in all plots, averaged 289 plants per acre. Two species, Cibotium chamissoi Kaulf. and Cibotium splendens (Gaud.) Krajina were present, but were considered together for the control ratings.

Effective control of treefern was not achieved with the single application of any of the herbicides tested (table 2). Brushkiller and Tordon 101 were the only herbicides that had a lasting effect on treefern. All rates of these two herbicides caused epinasty (downward curvature caused by uneven growth) of young treefern fronds. Higher rates caused more twisting than did lower rates:

	<u>Herbicide and rate per acre:</u>	<u>Treeferns show- ing epinasty</u> (percent)
Brushkiller:	2 lbs.	15
	4 lbs.	20
	8 lbs.	26
Tordon 101:	1/2 gal.	8
	1 gal.	12
	2 gals.	26

This effect was visible one month after treatment and was confined to the younger, more succulent fronds; fronds that appeared after these chemicals were applied showed no epinasty. Only a few treeferns were killed.

Diquat produced a good short-term effect, with many fronds severely burned, but two months later the same plants had green and vigorous new fronds. Pentachlorophenol burned a few scattered ferns severely, but most escaped visible injury. Def had no noticeable effect.

Woody Shrubs

A large variety of woody shrubs were associated with treefern in the spray plots. Mamaki (Pipturus albidus (H. and A.) Gray) was the most abundant species at both sites and was almost completely controlled by all rates of brushkiller and Tordon 101 (fig. 3). The other herbicides gave poor results (table 3). Diquat and pentachlorophenol caused only occasional branch kill (fig. 4), and Def had no noticeable effect.

Only 10 percent of the mamaki plants sampled had sprouted after one year.

Many other species were present at the study sites in numbers too small for good samples. Effects of the herbicides on these species appeared to be much the same as on mamaki. Table 4 summarizes the observations recorded on these woody shrubs.

Other Ferns, Vines, and Woody Climbers

Amaumau fern (Sadleria cyatheoides Kaulf.) occurred at both study sites. New fronds were very sensitive to both brushkiller and Tordon 101, and hence were easily killed. Older fronds were less

Figure 3.--Tordon 101 and brushkiller were very effective on woody shrubs. Eight pounds of brushkiller resulted in almost complete control of mamaki in this half-acre plot. Treefern was little affected.



Figure 4.--Contact herbicides were not effective. One gallon of penta weed-killer caused only minor tip kill of mamaki in this half-acre plot.

Table 3.--Effect of broadcast chemical sprays on mamaki, after 1 year, island of Hawaii, 1964.(Basis, 495 plants)

Herbicide	Rate per acre	Kulani ¹		Holualoa		Average	
		Height	Degree control ²	Height	Degree control	Height	Degree control
		Feet		Feet		Feet	
Brushkiller	2 lbs.	11	4.7	12	4.2	12	4.4
	4 lbs.	9	4.8	13	5.0	11	4.9
	8 lbs.	10	4.5	17	4.8	14	4.6
Tordon 101	1/2 gal.	--	--	11	4.4	11	4.4
	1 gal.	--	--	13	4.4	13	4.4
	2 gal.	--	--	11	5.0	11	5.0
Diquat	1/2 pt.	--	--	12	2.0	12	2.0
	1 pt.	--	--	13	1.9	13	1.9
	2 pt.	--	--	10	2.4	10	2.4
Penta weed-killer	1/2 gal.	12	1.0	14	1.6	13	1.3
	1 gal.	11	1.0	12	1.9	12	1.4
	2 gal.	8	1.1	12	1.8	10	1.4
Def	1 pt.	8	1.0	13	1.0	10	1.0
	2 pt.	11	1.0	11	1.0	11	1.0
	4 pt.	7	1.0	13	1.0	10	1.0

¹Tordon 101 and diquat were not tested at Kulani.

²Control evaluated on the basis of a rating index as follows:

- 1 = no apparent control
- 2 = slight control
- 3 = moderate control
- 4 = good control
- 5 = complete control (plant killed).

Table 4.--Reaction of several woody shrubs to brushkiller (2,4-D/2,4,5-T), after 1 year, island of Hawaii, 1964

Scientific name	Common name	Reaction ¹	Sprouting observed
<i>Acacia koa</i>	koa	S	No
<i>Clermontia gaudichaudii</i>	haha	S	No
<i>Coprosma ernodeoides</i>	kukae-'ua'u	S	No
<i>Styphelia tameiameia</i>	pukiawe	R	No
<i>Ilex anomala</i>	kawa'u	VS	No
<i>Metrosideros collina</i>	'ohi'a-lehua	R	Yes
<i>Myoporum sandwicense</i>	naio	S	No
<i>Psidium guajava</i>	guava	VS	Yes
<i>Rubus hawaiiensis</i>	'akala	S	Yes
<i>Scaevola</i> spp.	naupaka	VS	No

¹Reaction evaluated on the basis:
 VS = very sensitive
 S = sensitive
 R = resistant.

affected. A large number of plants were killed. False staghorn fern (*Dicranopteris linearis* (Burm.) Underw.) occurred in scattered clumps at Holualoa and was easily killed with brushkiller.

Lemi-wai (*Passiflora ligularis* Juss.) was very dense in several plots at Holualoa. Brushkiller and Tordon 101 had little lasting effect on this troublesome vine. 'Ie'ie vine (*Freycinetia arborea* Gaud.) was present in a few plots. It appeared to be resistant to all herbicides tested.

Conclusions and Future Work

Almost complete control of woody shrubs was achieved with both Tordon 101 and brushkiller. All rates of these two herbicides produced a satisfactory effect. The excellent control of woody shrubs scattered among dense treefern indicates that good spray coverage was achieved with the turbine blower. Results on treefern, although poor, was sufficiently encouraging to warrant additional study. Observations indicate that either the herbicides tested did not penetrate the treefern tissues in sufficient quantity to cause death, or that translocation is poor within the treefern genus. Repeat spray applications or timing of spray applications to coincide with periods of active treefern growth may solve these problems. No contact herbicide³ tested had a lasting effect on any species. Future work should be performed primarily with translocated herbicides.⁴

Four new studies, aimed primarily at more complete control of treefern, were started in 1965. One study tests the effects of repeat spraying, nozzle sizes, and spray volume on treefern. A second tests the effects of different carriers and nozzle sizes. A third screens additional herbicides on treefern. The fourth tests different dates of spraying for the control of treefern. These studies will be completed in 1967.

Acknowledgments

The author wishes to acknowledge the efforts of Jay R. Bentley, Charles A. Graham, George T. Hashimoto, and William S. Null in planning and carrying out these studies.

This research was conducted by the U. S. Forest Service in cooperation with the Forestry Division of the Hawaii Department of Land and Natural Resources, Kulani Honor Camp of the Hawaii Department of Social Services, and the Bernice P. Bishop Estate. Herbicides were supplied by the Dow Chemical Company and the American Cyanamid Company.

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³A herbicide that kills primarily by contact with plant tissue rather than as a result of translocation.

⁴A herbicide that is moved within the plant from the point of entry