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A provisional assessment of **triclopyr herbicide** for use in Lake States' forestry

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A PROVISIONAL ASSESSMENT OF TRICLOPYR HERBICIDE FOR USE IN LAKE STATES' FORESTRY

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A new herbicide is needed that controls a broad spectrum of hardwoods, is safe for releasing conifers, and breaks down rapidly in the forest environment without moving from the site. The commonly used 2,4-D [(2,4-dichlorophenoxy) acetic acid] does not control most northern hardwoods; though 2,4,5-T [(2,4,5-trichlorophenoxy) acetic acid] controls more hardwoods (especially oaks), it may not continue to be available for forest management. Picloram (4-amino-3,5,6-trichloropicolinic acid) controls most Lake States hardwoods (Perala 1971, 1974, Perala and Williams 1970), but because it is such a broad spectrum herbicide its use will likely be limited to site preparation rather than for aerial release of conifers.

A recently developed chemical, triclopyr, (3,5,6-trichloro-2-pyridinyloxyacetic acid), controls a broad spectrum of broadleaf weeds (Haagsma 1975). It is taken up by both foliage and roots, is readily translocated in the growing plant, and induces auxin-like responses similar to the action of 2,4-D and 2,4,5-T. It is available as a water soluble triethylamine salt in Garlon 3A Herbicide[1] comprising 3 lbs a.e. per gallon. Breakdown in the soil depends on microbial activity when temperature and moisture are favorable. In the laboratory, 50 percent breakdown occurs in 10 to 46 days at 35C. Field trials elsewhere show the breakdown rate is intermediate between that of 2,4,5-T and picloram (Haagsma 1975). Toxicity to birds and fish is very low, and moderate to animals.

The objectives of this study were threefold: (1) compare rate-response curves of some typical Lake States hardwoods to triclopyr, (2) estimate the persistence and mobility of triclopyr in forest soil, and (3) evaluate the safety of triclopyr to white spruce during aerial release and for planting after site preparation. Aerial release of conifers is not a currently registered use of triclopyr. However, forest site preparation is a registered use as long as conifer planting is deferred until six months after treatment.

STUDY AREA

The study area is located near Grand Rapids, Itasca County, Minnesota. The topography is rolling and soils are loamy but variable, ranging from sand to silt to clay. Soil drainage ranges from poorly-to well-drained. Mean July temperature and April to September rainfall are 66° F and 18 inches, respectively. The dominant vegetation is pole-size northern hardwood forest (table 1). According to Kuchler (1964) the potential natural vegetation is maple-basswood forest, indicating relatively high soil fertility. Some of the forest has been converted to white spruce [*Picea glauca* (Moench.) Voss] plantations where quaking aspen suckers comprise 86 percent of competitors and no other species makes up more than 5 percent.

TREATMENTS AND METHODS

Triclopyr, alone at three rates and in combination with 2,4-D and Tordon 101 Mixture[2] Herbicide, was compared with Tordon 101 Mixture as a standard in six 5-acre site preparation treatments (table 2). Triclopyr was also compared to a standard conifer release formulation of 1:1 mixture of

[1]*Mention of trade names does not constitute endorsement of the products by the USDA Forest Service.*

[2]*The Dow Chemical Company. Contains 2 lbs. 2,4-D + .54 lbs. a.e. picloram per gallon as triiso-propanol-amine salts.*

Table 1.—*Average basal area and DBH for sample trees for six site preparation treatments*

Species		Stand basal area[1]	Sample tree quadratic mean d.b.h.
Common name	Scientific name		
		ft^2/acre	inches
White birch	*Betula papyrifera* Marsh.	15.8	7.2
Red maple	*Acer rubrum* L.	12.3	5.5
Quaking Aspen	*Populus tremuloides* Michx.	36.5	9.5
Northern red oak	*Quercus rubra* L.	17.7	8.1
American basswood	*Tilia americana* L.	3.9	7.0
Sugar maple	*Acer saccharum* Marsh.	16.2	3.8
Others[2]		4.2	6.7
Total or Average		106.6	7.7

[1]Also mean number of trees sampled per treatment.

[2]Balsam poplar (*Populus balsamifera* L.), green ash (*Fraxinus pennsylvanica* Marsh.), American elm (*Ulmus americana* L.), eastern hophornbeam (*Ostrya virginiana* (Mill.) K. Koch.), yellow birch (*Betula alleghaniensis* Britton).

Table 2.—*Rates of application of various chemicals for different treatments*

Treatment	Chemical				
	Triclopyr[1]	2,4-D	Picloram[2]	2,4,5-T[3]	Total
	... Rate, lbs a.e. per acre ...				
Site Preparation[4]					
1	1.5	—	—	—	1.5
2	3.0	—	—	—	3.0
3	4.5	—	—	—	4.5
4	1.5	[5]4.0	—	—	5.5
5	1.5	[2]2.0	0.5	—	4.0
6	—	[2]2.0	0.5	—	2.5
Spruce Release[6]					
7	0.375	—	—	—	0.375
8	0.75	—	—	—	0.75
9	1.125	—	—	—	1.125
10	—	[3]1.5	—	1.5	3.0

[1]As Garlon 3A Herbicide.

[2]As Tordon 101 Mixture.

[3]As Esteron Brush Killer.

[4]In 8 or 10 gallons water mix per acre; 5 acres per treatment.

[5]As Esteron 99 Concentrate.

[6]In 4 gallons water mix per acre; 10 acres per treatment.

2,4-D and 2,4,5-T[3] (table 2) on four 10-acre areas. All areas were sprayed on the morning of July 28, 1975, by a helicopter equipped with a conventional boom fitted with "raindrop" nozzles for drift control. Temperatures that afternoon and for the next 3 days reached the low 90's. Calculated soil moisture (Thornthwaite and Mather 1955) on the 28th was 8.93 inches for the upper 6.7 feet of soil profile, or 74 percent of field capacity. The GDD sum [growing degree days, °F = ½ (daily maximum + daily minimum) − 40; positive values summed over period of interest] for the 1975 season had reached 2073° F. Soil moisture and GDD were calculated using standard weather station data (U.S. Department of Commerce 1975) averaged for Pokegama Dam and Remer #2 located 020°, 12 miles; and 250°, 11.5 miles, respectively, from the study site. Neither soil moisture nor GDD sum (an index of plant maturity) were considered limiting, but the high temperatures during and after spraying may have increased herbicide volatility or reduced herbicide activity. Winds during spraying did not exceed 5 mph.

On April 27, 1976, 100 white spruce 2-2 stock were planted in each of the six site preparation treatments. On May 11 and 12, 1976, forty 0.8-inch diameter soil cores were extracted for a bioassay for residual herbicides on a systematic grid from each of site preparation treatments 1, 2, 3,

[3]*Esteron Brush Killer, the Dow Chemical Company. Contains 2 lbs. per gallon each of 2,4-D and 2,4,5-T propylene glycol butyl ether esters.*

and 6 (table 2) and from an adjacent untreated area. The soil cores were separated into 0- to 4-inch and 4- to 12-inch strata and randomly combined into four composite samples of ten per stratum. This method is believed to provide estimates of 10 percent, 95 percent confidence for most soil properties (Alban 1974), including, presumably, those that would influence herbicide behavior in the soil. The samples were stored at 38° F until a greenhouse bioassay similar to Leasure's (1964) was begun in June. Soybeans were planted in the herbicide treatment samples and in control samples spiked with a standard series of 0, 10, 100, and 1,000 ppb of either triclopyr or picloram (as Tordon 101 Mixture). After 22 days, plants were compared visually, harvested, ovendried, and weighed. Residual herbicide in treatment samples was assayed by interpolating from dose-response curves (fig. 1) developed from the standard series plant dry weights. The assay was confirmed by the visual comparisons.

One year after treatment 10 sample points were systematically located down the center of each of the six site preparation treatments. A 10-basal area factor prism was used to select an average of 11 sample trees at each point for dbh measurements, crown kill estimates to the nearest 10 percent, and presence of sprouting. In each of the four conifer release treatments, 40 white spruce were systematically selected and rated for release effectiveness based on estimated number of years before need for another release (0 = immediate need, 20 = 1 year . . . 100 = 5 or more years), and herbicide injury to the spruce.

RESULTS AND DISCUSSION

Bioassay.—The dose-response curves (fig. 1) were constructed from standard series aerial weights of soybeans for triclopyr, and the entire plant for picloram. Soybeans weighed more when grown

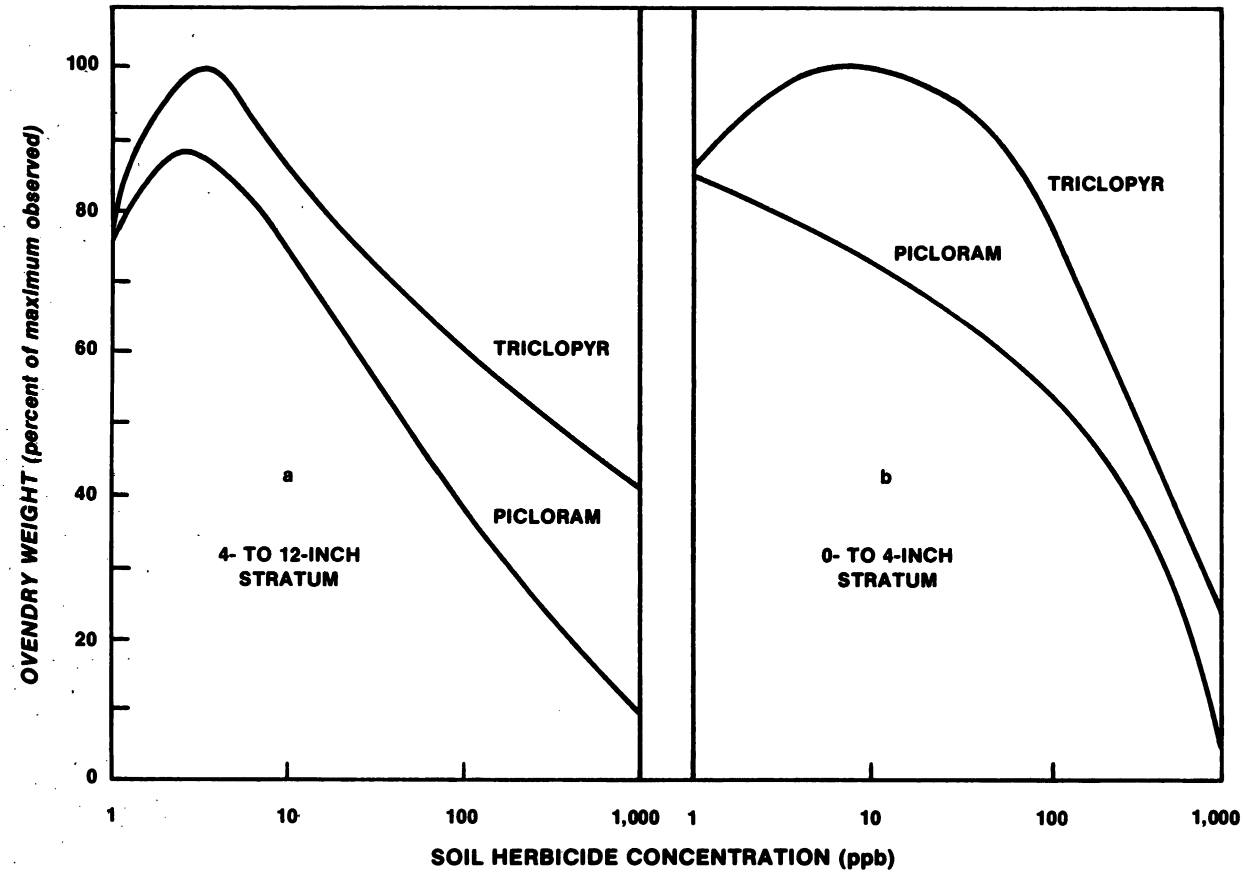

Figure 1.—*Dose-response curves for soybeans grown in control soils spiked with 0, 10, 100, and 1,000 ppb triclopyr or picloram (as acid equivalents). In the figure, 0 ppb is assigned a value of 1 ppb to accommodate the logarithmic scale. The peak response in (a) is estimated from treatment sample data (see text).*

with 10 ppb triclopyr than when grown without herbicide in both the 0- to 4-inch and 4- to 12-inch strata. Furthermore, plants grown in the 4-to 12-inch strata from both the triclopyr and picloram treatments exceeded the weight of 10 ppb plants. Apparently, soybean growth is stimulated by both herbicides at low concentrations. Accordingly, the dose-response curves were modified by extrapolating to the peak response found in treatment soils. In the future, standard series soil dosages should extend into the 1-10 ppb range and perhaps even lower.

The soybean bioassay recovered less than 10 percent of the triclopyr applied for site preparation and about 13 percent of the picloram, and practically all herbicide was found in the 0- to 4-inch stratum (table 3). Even with 16.4 inches of precipitation between herbicide application and soil sampling (U.S. Department of Commerce 1975, 1976), both triclopyr and picloram strongly resisted leaching.

It cannot be interpreted that the unrecovered herbicide was broken down entirely by microbiological activity because the amount of herbicide actually reaching the forest floor is unknown. Other losses include volatilization, photo-degradation, drift, and vegetation absorption and uptake, none of which were measured here. However, triclopyr was nearly as persistent as picloram after 2012 GDD between application and sampling. This is 54 percent of 1975 seasonal GDD at the study site.

The percent recovery of triclopyr varied inversely with rate applied (table 3). This anomaly has been noted before for picloram (Perala 1974). One possible explanation is that low application rates are insufficient for the rapid adaptation and multiplication of soil micro-organisms responsible for herbicide degradation.

Survival and growth were good in the planted white spruce in the site preparation treatments and no detectable herbicide injury was found. In light of the soybean bioassay, the retention of herbicide in the 0- to 4-inch soil stratum effectively prevented herbicide contact with seedling roots.

Site preparation.—Top-kill increased with rate of triclopyr applied and varied considerably by species (fig. 2). White birch was easily top-killed as was red maple at the highest rate. Extrapolation to rates of 6 lbs a.e. per acre suggest good top-kill of red oak and basswood as well. Quaking aspen and especially sugar maple were much more resistant.

Triclopyr top-killed white birch and red maple better than did Tordon 101 Mixture, but the latter was superior on quaking aspen, basswood, and sugar maple (table 4). When triclopyr was applied in combination with 2,4-D or Tordon 101 Mixture, top-kill was either only slightly changed, or in the

Table 3.—*Recovery of triclopyr and picloram from four site preparation treatments by soybean bioassay*

Treatment	Soil weight per acre	Maximum possible herbicide concentration	Concentration recovered[1]	Recovery
0- to 4-inch STRATUM				
	lb × 10⁻⁶	*ppb*	*ppb*	*Percent*
1 (Triclopyr)	0.711	[2]2,110	200	9.5
2 (Triclopyr)	.745	4,030	220	5.5
3 (Triclopyr)	.768	5,860	140	2.4
6 (Picloram)	.745	670	86	12.8
4- to 12-inch STRATUM				
1	2.049	[3]660	4	0.6
2	2.212	1,290	4	0.3
3	2.196	2,000	4	0.2
6	2.275	190	3	0.5

[1]Concentration recovered is based on the ovendry weight of the total plant for picloram and on aerial parts only for triclopyr. Plants harvested 22 days after sowing.

[2]Figures in this column for the 0- to 4-inch stratum assume all herbicide reached the soil surface and remained in the 0- to 4-inch stratum.

[3]Figures in this column for the 4- to 12-inch stratum assume herbicide not recovered in the 0- to 4-inch stratum leached unaltered to, and accumulated in, the 4- to12-inch stratum.

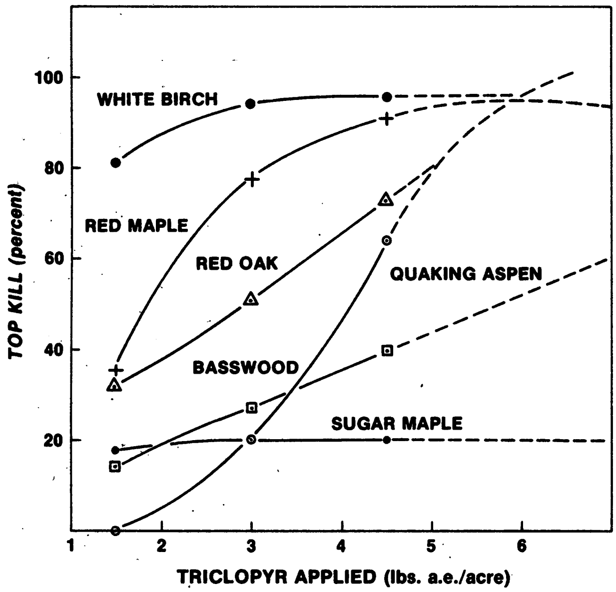

Figure 2.—*Hardwood top-kill response curves to triclopyr applied at 1.5, 3.0, and 4.5 lbs a.e. per acre. Dashed lines are extrapolated trends.*

Table 4.—*Top-kill of species in site preparation tests 4, 5, and 6*

	Topkill		
Species	Triclopyr + 2,4-D	Triclopyr + Tordon 101 Mixture	Tordon 101 Mixture
	....	Percent	....
White birch	100 (+4)[1]	69 (−27)	61 (−31)
Red Maple	57 (−37)	18 (−70)	35 (−34)
Quaking aspen	50 (+2)	53 (+17)	61 (+38)
Northern red oak	84 (−4)	50 (−16)	53 (+9)
American basswood	i[2]	58 (+13)	100 (+88)
Sugar maple	8 (−12)	21 (+1)	73 (+53)

[1]Numbers in parentheses indicate departures from the triclopyr rate-response curves in figure 2 on an equivalent total herbicide rate basis.
[2]i=Insufficient observations.

case of red maple and white birch (especially with Tordon 101 Mixture), greatly reduced. Thus, little or no synergistic action of triclopyr in combination with 2,4-D or picloram is evident. Rather there seems to be antagonistic or blocking action with strong species interaction.

A plot of sprouting percent over top-kill for triclopyr (fig. 3) indicates the root-kill character of the herbicide. Triclopyr tended to root-kill basswood, sugar maple, and red oak when top-kill was high. White birch sprouting was controlled moderately well but sprouting of red maple was poorly controlled and suckering of aspen not at all.

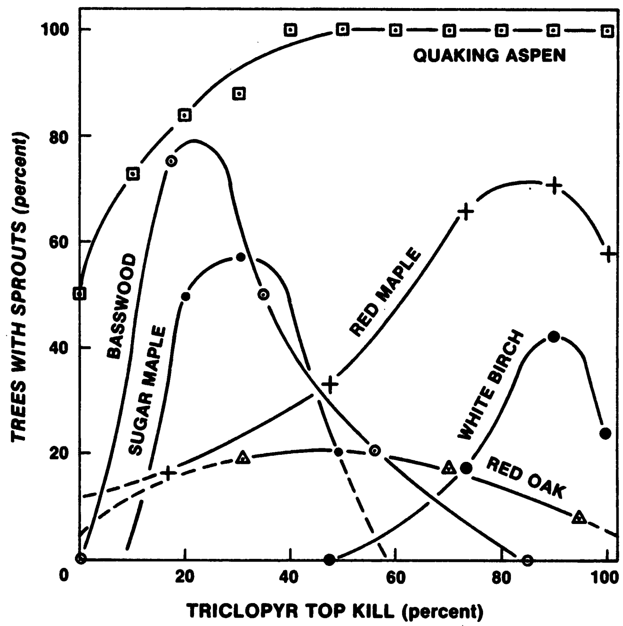

Figure 3.—*Hardwood sprouting response curves over increasing top-kill by triclopyr. Dashed lines are extrapolated trends.*

Sprouting of these species in treatments 4, 5, and 6 was compared to the sprouting expected if sprouting followed the curves in fig. 3. Tordon 101 Mixture (either alone or with triclopyr) controlled sprouting as well or better than triclopyr alone, especially aspen suckering (table 5).

Spruce release.—Triclopyr effectively released white spruce at a rate of 1⅛ lbs a.e. per acre (fig. 4). Effectiveness was equal to that of 2,4-D + 2,4,5-T at 3 lbs per acre. Extrapolation of the effectiveness-rate response curve suggests that rates of 1.5 - 2.0 lbs a.e. per acre would exceed 90 percent effectiveness. It seems unlikely that this increased rate would significantly injure white spruce since absolutely no herbicide injury was found at all.

Table 5.—*Sprouting of species in site preparation tests 4, 5, and 6*

Species	Sprouting		
	Triclopyr + 2,4-D	Triclopyr + Tordon 101 Mixture	Tordon 101 Mixture
	.... Percent		
White birch	59 (+31)[1]	20 (+2)	18 (+1)
Red maple	25 (−14)	14 (−4)	0 (−25)
Quaking aspen	91 (−3)	64 (−31)	47 (−47)
Northern red oak	13 (0)	6 (−12)	0 (−16)
American basswood	i[2]	0 (−23)	0 (0)
Sugar maple	13 (+8)	0 (−26)	4 (−6)

[1]Numbers in parentheses indicate departures from the triclopyr sprouting curves in figure 3 on an equivalent top-kill basis.

[2]i=Insufficient observations.

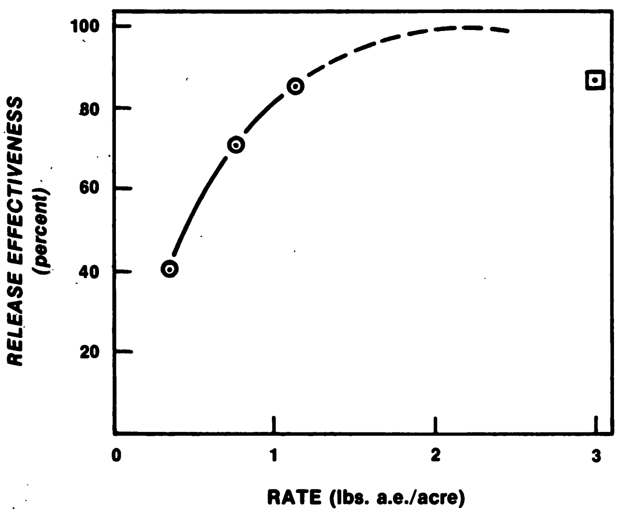

Figure 4.—*Rate response curves showing the effectiveness of conifer release from competing vegetation (primarily aspen suckers) in a white spruce plantation sprayed with triclopyr at rates of 0.375, 0.75, and 1.125 lbs a.e. per acre. Circles = triclopyr; dashed line = extrapolated trend; square = 2,4-D + 2,4,5-T at 3 lbs a.e. per acre.*

CONCLUSIONS

1. Triclopyr and picloram are unlikely to be leached out of intact forest floor and upper soil strata high in organic matter.
2. Triclopyr and picloram degradation rates in forest floor do not differ greatly during at least the first half-season (measured in GDD) after application.
3. White spruce bare-root stock may be safely planted where the forest floor is undisturbed the next spring after site preparation with either triclopyr or picloram.
4. White birch and red maple are readily top-killed with 4.5 lbs a.e. per acre triclopyr. Rates of 6 lbs per acre would likely top-kill red oak and basswood as well.
5. Sugar maple and quaking aspen are more readily top-killed with Tordon 101 Mixture than with triclopyr.
6. Triclopyr mixtures with 2,4-D or Tordon 101 Mixture are not as effective as triclopyr or Tordon 101 Mixture alone at the same total rate.
7. Compared to triclopyr, Tordon 101 Mixture reduced sprouting.
8. Rates of 1-2 lbs a.e. triclopyr are highly effective and safe for release of white spruce when sprayed at about 2100 seasonal GDD (2-3 weeks after shoot growth is completed).
9. Further study should test forestry uses of triclopyr at higher rates than used in this study.

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