Controlling Individual Junipers and Oaks with Pelleted Picloram

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Abstract

Applications of pelleted picloram to individual plants of alligator juniper, one-seed juniper, Utah juniper, gambel oak, and shrub live oak in north central Arizona showed that a high rate application, 3.6 g acid equivalent (a.e.) picloram (4-amino-3,5,6-trichloropicolinic acid) per meter of juniper height or meter² of oak clump crown cover, controlled each of the species. However, only Utah and alligator junipers were consistently controlled by lower rates, 1.8 g a.e. or less per unit of plant height. Regression formulas were developed to determine estimates of the amount of herbicide needed for effective control. Large scale pilot trials were done to expand application of results.

Since near the beginning of this century, attempts have been made to control junipers and oaks on western rangelands. In Arizona alone, more than 600,000 ha of pinyon-juniper ranges were cabled, chained, or bulldozed in the 1950's and 1960's (Cotner 1964). Many of these areas are being reinvaded by junipers and invasion of grassland areas is still occurring (Johnsen and Elson 1979). Interest has increased in the possible use of herbicides to control these trees and shrubs as energy costs have increased and raised the cost of mechanical control methods.

Systematic testing of chemical to control junipers and oaks on rangelands began in the late 1930's. Since then many herbicides have been evaluated, but few were effective. Picloram is one of the effective herbicides.

Pelleted picloram has been reported effective for controlling shrub live oak *(Quercus turbinella)* (Davis and Pase 1969), for control of single leaf pinyon *(Pinus monophylla)* (Young and Evans 1976), and several juniper species (Johnsen 1966, Schuster 1976, Ueckert and Whisenant 1982, Young et al. 1982). Little has been reported on the use of picloram for control of alligator juniper *(Juniperus deppeana),* one-seed juniper *(J. monosperma),* Utah juniper *(J. osteosperma),* gambel oak *(Q. gambelli),* and shrub live oak. Each species is widespread in Arizona and New Mexico; Utah juniper and gambel oak are also widespread in Colorado, Utah, and Nevada. These species have encroached upon range and forest areas and attempts are being made to reduce their invasion. Alligator juniper and the oaks have vigorous regrowth if the top growth is damaged, making them very difficult to control.

This report summarizes results of a widespread series of trials, including large-scale trials, to determine the effects of pelleted picloram applied to small, individual juniper trees and clumps of oak regrowth.

Procedures

Test Areas

Sixteen different locations in northcentral Arizona were used; all were at elevations between 1,500 and 2,000 m. The 2 drier locations, receiving 300 to 350 mm of precipitation annually, are: Deadman, 48 km north of Flagstaff on the Coconino National Forest, and Red Mountain, 43 km northwest of Flagstaff on the Kaibab National Forest. Delta Tank, on the Kaibab National Forest 10 km east of Ashfork, was intermediate in moisture, receiving 380 to 400 mm of precipitation. All the other locations receive 400 to 460 mm of precipitation annually. On the Coconino National Forest are: Watershed 12, 50 km southeast of Flagstaff; Blue Grade, 59 km south of Flagstaff; Apache Maid, 42 km southeast of Flagstaff; and Cedar Flat, 26 km east of Camp Verde. On the Kaibab National Forest is Pipeline, 14 km northeast of Williams. On the Prescott National Forest are: Turkey Creek, 10 km west, and Juniper Spring, 1 km north of the Walnut Creek Work Center, North Pasture, Pasture C, Red Tank, and Hookity H, 8 to 11 km northwest of Camp Wood. McInturf is located on the Tonto National Forest 11 km north of Young. Hat Tank is on private land

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5 km west of Williams. All locations receive some snow in the winter and thunderstorms in the summer, with dry springs and fall. The soils are described in Table 1. The target species and relative plant sizes at each location are listed in Tables 2 and 3. Each treatment site was relatively level and representative of major vegetation types of the area. Blue grama *(Bouteloua gracilis)* is the main understory plant at each site. All of the small-scale study areas were accessible throughout the year. None were near water tanks or drainage ways.

Table 1. Soil series and classification at each study site.

Soil Series	Classification	Locations
Broiller	Fine, Montmorillontic Agric Cryoborolls Mollisols	Pasture C, WS-12, Hat Tank
Lonti	Fine, mixed, mesic Ustollic Haplargids Aridisols	Hookity H, North Fork, Pasture C, Juniper Springs Turkey Creek
Naegelin	Fine, Montmorillontic, mesic Udic Haplustalfs Alfisols	McInturf
Pastura	Loamy, mixed, mesic, shallow Ustollic Paleorthids Aridisols	Delta Tank
Springerville	Fine Montmorillontic, mesic Typic Chromusterts Vertisols	Blue Grade Delta Tank Cedar Flat
Thunderbird	Fine, Montmorillontic, mesic Typic Argiustolls Mollisols	Red Tank, Pasture C, Red Mountain, Pipeline Apache Maid, Deadman

Materials

A pelleted formulation containing 10% acid equivalent (a.e.) of picloram by weight was used. However, limited tests were done with a formulation containing 5% a.e. picloram on alligator juniper at Apache Maid and on Utah juniper at Delta Tank in 1973, and on alligator juniper at McInturf in 1978.

Measured amounts of pellets were applied. Initially, a household measuring tablespoon was used. This held an average of 17.8 g of 10% pellets (3.2 mm diameter by 3.2 mm long), or 1.8 g a.e. of picloram. In the McInturf, Cedar Flat, and the pilot trials, the measure used held 14.2 g of pellets (3.2 mm diameter by up to 9.5 mm long) or 1.4 g a.e. of picloram with 10% pellets or 0.7 g a.e. of picloram with 5% pellets.

Methods

Testing began in 1963 and continued through 1980. Application dates, species, locations, rates, and numbers of plants or size of treated areas are shown in Tables 2 and 3. Most of the small-scale tests consisted of plots of 10 individual trees or oak clumps in randomized block experimental design with 3 replications except in the initial test in 1963, which had only 10 plants for each species. Untreated plots were included in all small-scale tests.

Trees selected for treatment were in invasion stands of scattered trees 0.6 to 3.0 m tall. Oak clumps were in scattered stands of recent regrowth following fire or mechanical disturbance and were 0.45 to 1.5 m high.

Trees and clumps were marked with numbered metal tags and their locations mapped. Tree heights and clump crown dimensions were measured to the nearest 15 cm.

Treatments at McInturf and Cedar Flat were applied onto trees on small plots. Individual plots were 6 m by 30 m at McInturf and 15 m by 30 m at Cedar Flat. There were 3 replications of each treatment in a randomized block design. The trees were not tagged but were mapped at Cedar Flat. All of the trees on a 1-ha area were treated at Juniper Springs.

Picloram pilot trial applications were done by Forest Service crews, and by a rancher's crew on the private land. Crews were

Table 2. Response of junipers and oaks three years after applications of pelleted picloram to individual plants, except it is two years after at McInturf and Cedar Flats.

Species	Location	Date treated (mo/yr)	No. Plants	Height Ave.	Height Range (m)	Rate (g)	Plants killed (%)
Gambel oak	WS-12	8/66	20	<1.5 m		3.6/m²	100
			20			2.4/m²	90
			20			1.8/m²	75
Shrub live oak	Blue Grade	7/63	10	1.5	0.9–1.5	1.8/m²	40
		9/63	30	0.9	0.8–1.1	1.8/m²	73
		8/66	30	0.7	0.5–1.2	3.6/m²	80
Alligator juniper	Pipeline	9/63	10	1.6	0.8–2.1	1.8/tree	90
		8/66	30	2.0	1.2–3.1	3.6/tree	100
	Turkey Creek	2/67	60	1.4	0.6–3.0	1.8/m ht.	90
			30	1.6	0.8–3.2	1.8/2m ht.	60
	Apache Maid	4/73	30	1.6	0.8–3.1	0.8/tree	50
			30	1.3	0.6–2.3	0.4/tree	30
	McInturf	1/78	86	1.0	0.3–3.1	0.7/m ht.	56
One-seed juniper	Deadman	9/63	10	1.4	1.1–1.8	1.8/tree	50
	Red Mountain	8/66	30	1.7	1.2–2.6	3.6/tree	100
Utah juniper	Delta Tank	9/63	10	1.0	0.6–2.1	1.8/tree	100
		8/66	30	1.5	0.8–2.3	3.6/tree	100
		4/73	30	1.8	1.1–2.9	0.8/tree	90
			30	1.7	0.8–3.1	0.8/tree	90
			30	1.5	0.6–2.6	0.4/tree	80
			30	1.5	0.8–2.4	0.4/tree	40
	Juniper Springs	2/67	98	1.0	0.6–2.4	1.8/m ht.	100
	Cedar Flat	5/80	31	1.6	0.3–3.1	1.4/m ht.	97
			33	1.3	0.3–2.7	0.7/m ht.	88

Table 3. Response of alligator and Utah junipers to pelleted picloram applied in pilot trials by National Forest crews and a private rancher in Arizona.

Species	Location	Date treated (mo/yr)	Area (ha)	Density (no/ha)	Time (worker h/ha)	Rate (g ae/m ht)	Plants killed (%)
Alligator juniper	Hat Tank	8/73	13	25	0.34	1.8	98
	Red Tank	7/77	10	815	0.91	1.4	83
	Hookity H	9/77	6	494	1.11	1.4	79
	North Fork	7/78	110	205	2.00	1.4	93
	Pasture C	7/78	142*	185	2.00	1.4	85
Utah juniper	Pasture C	7/78	142*	185	2.00	1.4	100

*Mixture of Utah and alligator juniper, species ratio not determined.

instructed on proper application methods and records were kept of worker hours, area treated, and materials used for each trial.

Treatments

Application of pellets were made to a band about 30 cm wide around the base of juniper trees by sprinkling pellets over the top of small trees and throwing pellets around the base of larger trees (Fig. 1). Pellets were applied to spots 1 m apart in the oak clumps. Application rates were from 0.4 to 3.6 g a.e. per tree or oak clump (Tables 2 and 3). Initial applications to junipers were made at fixed rates per tree, regardless of tree size within the limits initially set. In subsequent trials, trees were treated with varying amounts of pellets according to tree height. Height was used as the measure of tree size because earlier experience with other pelleted herbicides had shown application crews were better able to quickly judge tree height than tree crown diameter or stem diameters of multiple stemmed trees.

Observations

Ocular estimates were made of damage to the top growth 1, 9, 12, 24, and 36 months after picloram application small-scale trials except at McInturf, where observations were made at 9 and 12 months, and at Cedar Flat at 25 months. Observations were continued as long as additional damage was evident, but maximum damage occurred usually within 2 years of treatment. Estimates of plants killed were made 3 years after treatment except at McInturf and Cedar Flat, where it was done after 2 years. Supplementary observations were made of damage to associated vegetation, soil moisture at time of treatment, rainfall before and after treatments, and phenological stage of the treated species and associated vegetation at the time of treatment.

In the pilot trials, observations were made 1 or 2 months after treatment, and then at the end of the first and second growing seasons after applications. Evaluation of plant damage on the pilot trials was done by estimating to the nearest 10% damage to the top growth of trees along narrow belt transects.

The results of the small scale tests were combined for all trials for each species and the data analyzed by linear regression to determine the most effective rate of picloram for the various size classes for each species.

Results and Discussion

Small-Scale Trials

In the small scale trials, picloram at 3.6 g per tree controlled each of the species (Table 2). Picloram at 1.8 g, did not give consistent control of the oaks or one-seed juniper. Picloram applications at lower rates than 1.8 g killed small alligator and Utah junipers consistently.

The rates of picloram needed to kill all treated juniper trees within certain size limits are summarized in Figure 2. One-seed juniper was the most resistant to picloram of the 3 junipers. Rates higher than 3.6 g are apparently required for consistent control of trees taller than 2 m.

Utah juniper is the most sensitive of these junipers to picloram. As little as 0.4 g of picloram will kill trees up to 1 m tall (Fig. 2).

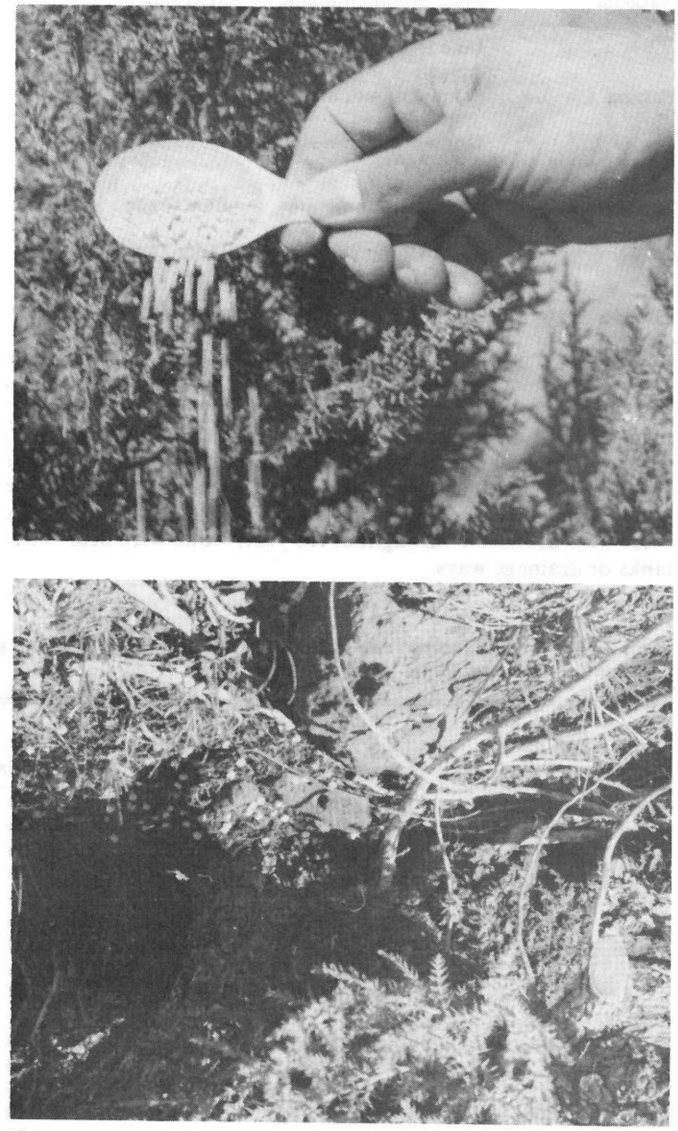

Fig. 1. *Application of pelleted picloram onto junipers and distribution of pellets around the tree base.*

such low rates require careful application to insure uniform coverage around the tree. It is possible that a granular formulation or lower concentration pellets would insure adequate coverage. This is indicated by the responses shown at Delta Tank in the 1973 trials. On the clay soil, the low rate application of a 5% formulation resulted in good control. However, the same rate applied to a loam soil nearby resulted in variable control. Picloram may have moved deeper into the loam soil more quickly and thereby was rapidly diluted, and thus caused less damage to the trees. Such soil effects have been previously examined (Herr et al. 1965): rapid movement of picloram occurs in light-textured soils and lower rate applications dissipate in the soil faster than higher rates. Concentrations of picloram were reported to be greatest in heavy textured soils with higher organic matter content (Herr et al. 1965); a situation we have at the base of juniper trees on clay soils. The linear regression: $Y = -0.95 + 1.50X$ ($r^2 = 0.93$) fits the data for control of Utah juniper. Y is the dosage in g a.e. of picloram, and X is tree height in m.

Alligator juniper is intermediate in sensitivity to picloram (Fig. 2). The top growth is easily damaged but the tree may sprout from

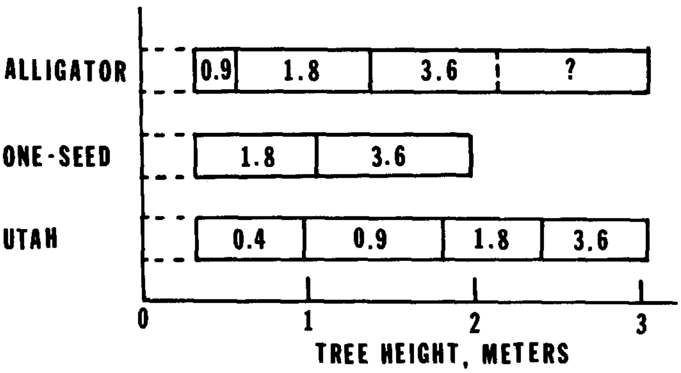

Fig. 2. *Amounts of picloram, g acid equivalent, to kill various sizes of small juniper trees.*

dormant buds at its base, along the stems, and from the roots (Jameson and Johnsen 1964). There may be several flushes of regrowth before an alligator juniper is killed. This is why an herbicide with a moderately long residue life is needed to control this species. Since there were few trees taller than 2.5 m in these studies, the upper limits of tree size that the 3.6 g rate would control is uncertain. Trees under 0.5 m were controlled with picloram at a rate of 0.9 g, trees from 0.5 m to 1.4 m by 1.8 g a.e., and trees from 1.4 m to about 2.3 m by 3.6 g. A linear regression formula of $Y = -0.26 + 2.18X$ ($r^2 = 0.99$) fits these data.

Results indicate that 1.8 g of picloram would kill a 1.4-m tall alligator juniper, 1-m tall one-seed juniper, or 2.3-m tall Utah juniper. Differences in soils, slope, organic matter, rooting depths, top growth density, and herbicide application may cause variations in reponses to picloram. Uniform coverage of the treatment band is necessary to obtain uniform responses. Studies by the author on translocation of dyes and chemicals from juniper roots into the top indicate little lateral movement of these materials in the stems, so each root provides transport to only a portion of the tree crown. This is further shown by old junipers with narrow strips of live tissue connected to single branches of the tree.

Pilot Scale Trials

The results of the 6 trials done on a larger scale are presented in Table 3. Only 1 trial on Utah juniper is reported. Most of the trees treated were under 2 m tall and excellent control was obtained. Additional tests are needed to confirm the suggested treatment rates to be used on Utah juniper. Such tests are under way but have not been in place long enough for any conclusions.

Almost all of the trees under 1 m tall were killed (Table 3). The larger trees varied in their response to picloram, especially those over 2 m tall. This may have been due to a change in application rates from those used in earlier studies. The original tests were done with a volume measure which contained 17.8 g of 10% pellets or 1.8 g of picloram. Due to changes in pellet size this dosage was changed to a weight basis of one-half ounce (14.17 g) and measuring scoops were calibrated to 14.2 g of pellets. Thus, each dose contained 1.4 g picloram rather than 1.8 g. With small trees this did not make much difference; but, as numbers of scoops per tree are increased, the difference becomes more important. The use of the regresson formula should alleviate this problem in the future.

The number of untreated trees in the pilot trials averaged about 13% and ranged from 1% to 27%. This is fewer than the average of 40% missed trees reported by Ueckert and Whisenant (1982) for treating small junipers in Texas. Small trees were also missed on plots in the small scale trials. Most of the trees missed were under 0.75 m tall, but some were almost 2 m tall. These small trees blend into the natural colors of the area and are difficult to locate, especially in bright sunlight. The fewest untreated trees occurred when crews moved through the area systematically. Crews which spread out and individually hunted for trees often missed entire groups of trees. Marking treated trees with survey ribbon along the edge of each treatment strip also helped reduce missed trees and saved time as the crew returned across the area.

It took from 0.34 to 2 worker-hours to treat a hectare of trees in the pilot trials (Table 3). The most rapid time was with the thinnest stand, 25 trees per ha, but the thickest stands were not the most time consuming. Our treatment times were both faster and slower than those indicated by Ueckert and Whisenant (1982) in Texas. The size of the treatment areas seem to be confounded in our treatment time meaurements. Smaller treatment areas were completed more rapidly than the larger projects. Variation in crew organization, treatment thoroughness, attitude of crew members, and variations in terrain are some factors affecting treatment time. Our observations indicate that time data from small area treatments can not be used to predict treatment times for larger areas.

The determination of material costs can be readily calculated if one knows the acreage to be treated, the average number of trees, and the average tree height. One can use the regression formula presented to determine the amount of herbicide needed to control an individual tree of the average height. This is then multiplied by the number of trees per hectare or acre, and then by the number of hectares or acres. This will give the total amount of a.e. picloram needed, this number is then converted to pounds, and multiplied by 10 to estimate the amount of 10% a.e. picloram pellets needed. A cost estimate for that amount of herbicide can be obtained from a supplier.

Very little damage was observed on vegetation adjacent to treated trees. Occasional untreated alligator junipers showed symptoms of herbicide damage. These trees may have been root sprouts from roots of treated trees. Jameson and Johnsen (1964) reported 17% of the alligator junipers in one area were root sprouts. The only damaged grasses and forbs observed were under or next to treated trees. Vegetation began growth under trees within a year of their death.

Picloram is currently a restricted use herbicide so an applicator must be certified by the state in which this herbicide is used (Martinelli et al. 1982). Small Utah and alligator junipers can be controlled selectively with pelleted picloram. Generally, stands made up of less than 330 trees per ha with trees averaging less than 2 m tall are suited to this type of treatment. Thus, pelleted picloram can be useful in reducing stands of invading Utah and alligator junipers or to maintain areas cleared of them in the past by bulldozing, cabling, or chaining.

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