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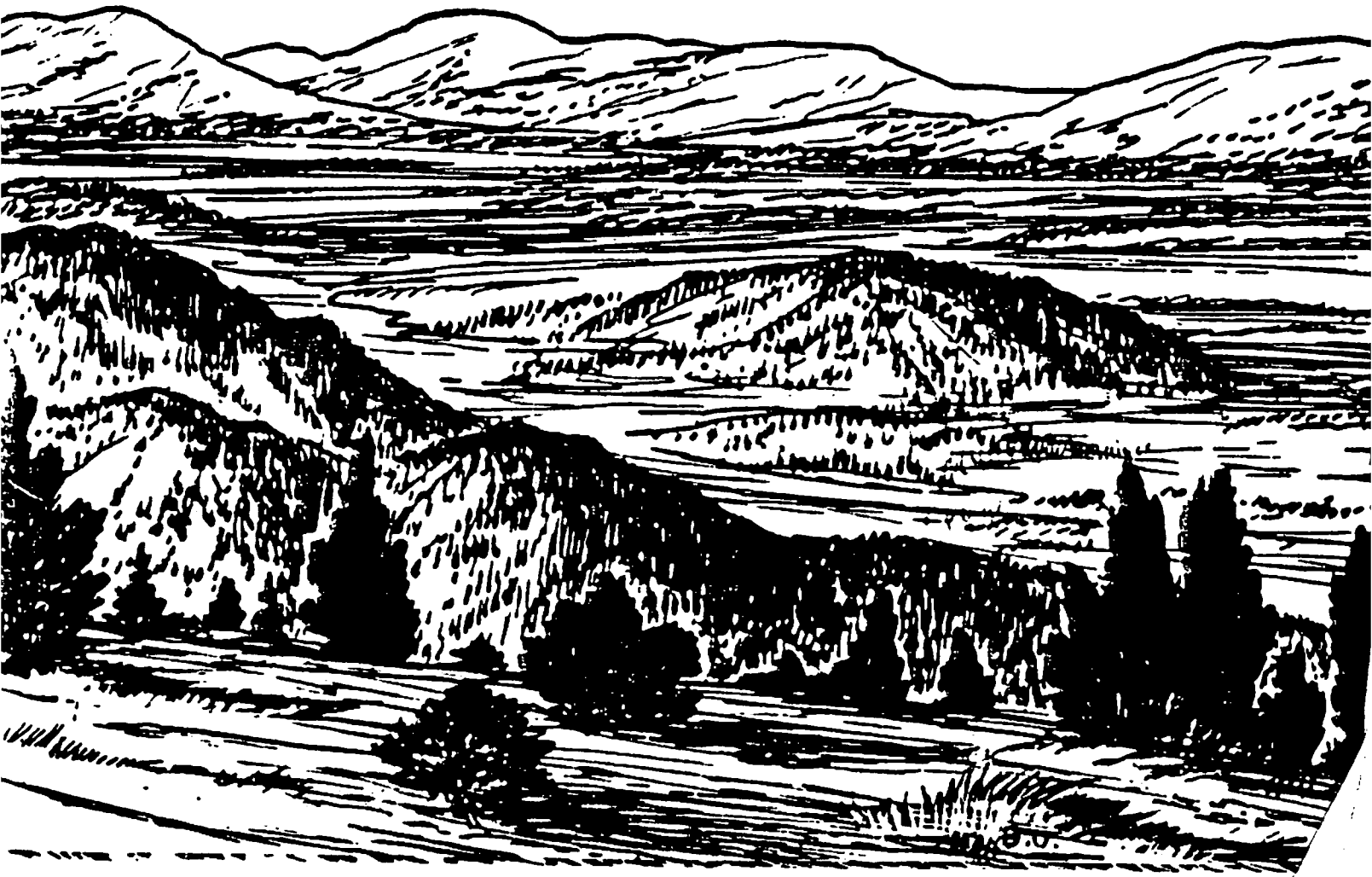

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RICHARD L. EVERETT, Project Leader, Intermountain Research Station, Forest Service, U.S. Department of Agriculture

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USING HERBICIDES FOR PINYON-JUNIPER CONTROL IN THE SOUTHWEST

Thomas N. Johnsen, Jr.

ABSTRACT: Pelleted picloram or tebuthiuron are being used to kill individual trees, to maintain chained or bulldozed areas, and to restore recently invaded grasslands on southwestern pinyon-juniper ranges. Good control of Utah juniper (*Juniperus osteosperma*) and pinyon (*Pinus edulis*), and variable control of one-seed juniper (*J. monosperma*) and alligator juniper (*J. deppeana*) have been obtained. Broadcast applications have been limited to experimental and demonstration trials but both herbicides successfully controlled Utah juniper and pinyon. Tebuthiuron severely damaged cool season grasses; picloram did little damage to grasses. Tebuthiuron controlled understory shrub live oak (*Quercus turbinella*) and picloram did not.

INTRODUCTION

Although attempts have been made to control junipers on southwestern rangelands since the beginning of this century, most control efforts have been made during the last 30 years. A total of about 1 1/2 million acres of pinyon-juniper ranges was chained, cabled, or bulldozed in Arizona alone during the 1950s and early 1960s (Cotner 1963). Many of these areas are now being reinvaded and junipers are still encroaching on Arizona grasslands (Johnsen and Elson 1979). A renewed interest in pinyon and juniper wood products has resulted in a need for methods to manage stands by selective thinning. Use of mechanical control methods is limited by increased energy and labor costs, limited suitable areas, and aesthetics. Therefore, interest in the use of herbicides to control junipers has increased.

This paper briefly reviews herbicidal control of alligator juniper (*Juniperus deppeana*), one-seed juniper (*J. monosperma*), and Utah juniper (*J. osteosperma*) and some of the problems of using herbicides on southwestern juniper stands. Herbicide terminology follows that suggested by the Terminology Committee of the Weed Science Society of America (Harger and others 1985).

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Thomas N. Johnsen, Jr., is Research Agronomist for U.S. Department of Agriculture, Agricultural Research Service, 2000 East Allen Road, Tucson, AZ 85719.

BACKGROUND

Juniper Characteristics

Junipers are difficult to control with chemicals: Johnsen (1963, 1967) has reviewed characteristics which cause this. Many juniper anatomical and morphological characteristics offer resistance to foliage applied herbicides. The compact, low-growing juniper crowns limit spray droplet penetration into the canopy, resulting in poor, uneven coverage. Mature juniper leaves are small, appressed, scalelike, and vertically oriented, which makes spray droplet impingement difficult. The exposed leaf surfaces have thick, waxy cuticles and a layer of fibers under the outer epidermis which resist herbicide penetration into the leaf. Stomata and thin epidermal layers are located on protected inner surfaces of the appressed leaves and are difficult for sprays to reach. A large resin gland is located inside the small leaf and may absorb herbicides which enter the leaf and prevent movement out of the leaf.

All junipers have dormant epicormic buds which grow rapidly when the top growth is damaged. Alligator juniper also has dormant basal and root zone buds which grow profusely when top growth is damaged (Jameson and Johnsen 1964) making this species particularly difficult to kill. Sprouts from these dormant buds normally break dormancy and grow for only a short period in the early spring and are resistant to short-persistence herbicides.

Junipers have a widespread shallow lateral root system. Johnsen (1962) found that lateral roots of one-seed juniper were often twice as long as the tree height. Thus the lateral root system would be readily exposed to soil-applied herbicides. Herbicides entering the roots would be translocated throughout the tree crown by the younger sapwood of the trunk.

Herbicide Trials

The results of efforts to control junipers and pinyons with herbicides during the past half century were summarized previously (Johnsen 1966a, 1966b; Evans and others 1975). Many herbicidal chemicals were tested but few were effective. Promising agents were: arsenic salts; AMS; 2,4-D; 2,4,5-T; polychlorinated benzoic acids; fenuron; picloram and karbutilate. Of these only picloram is still available to control junipers on rangelands. In more recent trials another herbicide, tebuthiuron, has been effective on Utah junipers (Johnsen 1977, 1979; Clary and others 1985).

HERBICIDES CURRENTLY USED

Picloram

Picloram has been used on junipers in the southwest since 1963 as either foliage sprays or soil applications. It has controlled a variety of juniper species, including Ashe juniper (J. ashei) (Dalrymple 1969), eastern redcedar (J. virginiana) (Dalrymple 1969; Buehring and others 1971), one-seed juniper (Johnsen 1966a, 1967; Johnsen and Dalen 1984), redberry juniper (J. pinchottii) (Schuster 1976; Ueckert and Whisenant 1982), rocky mountain juniper (J. scopulorum) (Fisser 1967), Utah juniper (Fisser 1967; Johnsen 1966a, 1967; Clary and others 1974; Johnsen and Dalen 1984), and western juniper (J. occidentalis) (Young and others 1982). Picloram gave variable control of alligator juniper (Johnsen 1967; Johnsen and Warskow 1966; Clary and others 1974; Johnsen and Dalen 1984). Although picloram has been effective as both spray and pelleted formulations, only the pelleted product containing 10 percent picloram is currently being used to control junipers.

Tebuthiuron

Tebuthiuron has been tested on junipers in the southwest since 1972 but is generally ineffective on all but a few juniper species. Western juniper (Britton and Sneva 1981), eastern redcedar (Scifres and others 1981), and redberry juniper (Ueckert and Whisenant 1982) were not controlled by tebuthiuron. Utah juniper has been controlled by tebuthiuron (Johnsen 1977, 1979; Clary and others 1985). One-seed juniper and alligator juniper have been controlled by high rate of tebuthiuron applied to individual trees but not by broadcast applications in Arizona (Brock 1985; Johnsen data on file).

APPLICATION METHODS

Individual Tree Treatment

Individual tree treatment is used to kill small junipers to maintain chained or bulldozed areas and to restore recently invaded grasslands in the southwest. Pelleted picloram or tebuthiuron is sprinkled over the top of small trees or under the canopy of larger trees to obtain uniform coverage around the tree within the canopy drip line. This treatment is most suited to small trees under 6-feet tall in stands of less than 200 trees per acre. Larger trees vary in response to this treatment and denser stands may require broadcast applications. Applications should not be made onto frozen or saturated soils as the herbicide may be moved away from the treated tree before it can enter the ground. Very little damage has been observed on plants away from trees treated with picloram. However, tebuthiuron may kill grasses and forbs several feet away from the tree, especially with high application rates on slopes.

Applications in the southwest have been made on the basis of tree height units. Earlier work with other herbicides indicated that applicators were better able to judge tree height more quickly than crown diameter, stem diameter, or crown area. There is also good correspondence between tree height and crown volume for the smaller trees, but larger trees often have irregular canopy shapes and foliage densities resulting in a poor relationship between tree height and amounts of live top growth.

Differences in soil and site characteristics including clay content, organic matter, slope, rooting depths, top growth density, and herbicide application uniformity may cause variations in responses to these herbicides.

Individual Utah junipers have been controlled equally well with picloram or tebuthiuron (Johnsen and Dalen 1984; Johnsen data on file). Rates as low as 0.7 g active ingredient of either herbicide per 3 feet of height control Utah juniper trees up to 9-feet tall. High rates, 3.6 g or more per 3 feet of height, of picloram or tebuthiuron kill one-seed juniper and alligator juniper but lower rates of 1.4 g or less per 3 feet of height have given erratic results. Johnsen and Dalen (1984) developed linear regression equations to determine the relationship between tree height and amount of picloram needed to control Utah juniper, one-seed juniper, and alligator juniper. The equations indicate that 1.8 g of picloram will kill a 4.5-foot tall alligator juniper, a 3-foot tall one-seed juniper, or a 7.5-foot tall Utah juniper. Picloram is superior to tebuthiuron for controlling one-seed juniper, but both herbicides control pinyons and alligator juniper equally well. Herbicide effects are quicker with picloram than tebuthiuron. Alligator juniper may regrow several times from dormant buds before the tree dies.

An average of about 13 percent of the trees in pilot trials were not treated, ranging from 1 to 27 percent (Johnsen and Dalen 1984), which is less than the 40 percent average reported by Ueckert and Whisenant (1982) when treating very small junipers. Most of the missed trees were under 2-feet tall, because small junipers blend into the natural colors of the area and are difficult to find. The fewest trees were missed when applicators moved systematically through treatment areas, erratic hunting for trees often resulted in entire groups of trees being bypassed. Marking treated trees along treated strip edges helped reduce the number of missed trees and saved time as applicators returned across the area. Johnsen and Dalen (1984) reported it took from 0.14 to 0.81 worker-hour to treat an acre. Treatment times varied with the size of treated areas, tree density, crew organization, crew attitudes, treatment thoroughness, weather, and terrain. Per acre treatment times were less for smaller areas than for larger areas with similar tree densities.

The amount of herbicide needed for individual juniper treatment projects is readily determined from the size of the area, average number of trees per acre, and the average tree height. The average dosage per tree times the number of trees on the area determines the amount of herbicide needed.

Broadcast Application

Experimental broadcast applications of picloram and tebuthiuron have controlled Utah juniper but responses have been variable with alligator and one-seed junipers. In Arizona, aerial applications of pelleted picloram and tebuthiuron at 0.8 or 0.9 pounds per acre, respectively, killed 80 percent of the Utah junipers. At these rates, picloram killed all of the pinyon but none of the shrub live oak, while tebuthiuron killed 67 percent of the pinyon and 85 percent of the oak. Applications of 2 pounds or more picloram or 1.6 pounds or more tebuthiuron per acre killed more than 90 percent of the Utah junipers. Only 17 percent of the shrub live oak was killed with 3.6 pounds of picloram per acre; 87 percent of the pinyon was killed with 4.4 pounds of tebuthiuron per acre. Variations in individual pinyon responses to broadcast tebuthiuron may be due to variations in pinyon root distributions, especially on rocky sites, and to limited movement of tebuthiuron in soils. Neither herbicide killed many alligator junipers with broadcast applications.

Both herbicides readily killed junipers on ridges and along slopes but left trees undamaged on deep soils or bottom land sites, particularly at the lower application rates. Thus, junipers may not be eliminated from large areas. This is similar to the results reported by Clary and others (1985) from tebuthiuron treatment of Utah juniper in Utah. Picloram usually has maximum effects within 2 years of application to junipers, whereas tebuthiuron may take as long as 4 years to achieve maximum effects.

Effects on Associated Vegetation

Grasses in Arizona, mainly blue grama and sideoats grama, present on aerially treated plots, were not damaged by either picloram or tebuthiuron. In smaller, hand-applied broadcast trials, up to 4 pounds picloram per acre did not damage established grasses. Tebuthiuron did not damage established perennial grasses with applications of 2 pounds or less per acre; however, rates of 4 pounds or more per acre killed cool season grasses. The lower rates of tebuthiuron delayed cool season grass establishment for several years. Current label directions restrict tebuthiuron application to no more than 2 pounds per acre, thus its use should harm few established grasses. Generally, if a residual stand of grass was present, good stands of grasses developed within 5 years on both picloram and tebuthiuron treated areas without reseeding. Crusted, bare soils remained bare indefinitely. Increased grass production resulted from release of established plants from juniper competition and establishment of new plants under and between dead trees. Few forbs or half-shrubs grew on picloram or tebuthiuron treated areas.

Treated areas open to grazing are closely grazed. Grazing management is needed to avoid overuse by both livestock and wildlife following herbicide broadcast treatment of junipers.

ACCEPTANCE OF HERBICIDES

In order to be used, an herbicide must be accepted both by potential users and the interested public. Generally, this means the herbicide must fill a need and be: 1) safe, 2) acceptable to the public, 3) effective, and 4) selective.

Need for Herbicides

In the past, numerous areas of southwestern pinyon-juniper were chained, cabled, or bulldozed. Concern about maintaining these areas, restoring newly invaded grasslands, and managing juniper woodlands caused examination of ways to control junipers. Limitations of other control methods, including increased costs, have stimulated interest in herbicides.
Chaining and cabling, the most widely used juniper control methods, are suited to mature, even-aged, nonsprouting junipers in stands of about 250 trees per acre or less. Small trees and dense stands are not suited to chaining or cabling. Excess debris and soil disturbance also limit public acceptance of chaining and cabling. Moreover, most areas in the southwest suited to these methods have already been treated.

Crushing nonsprouting junipers with specialized equipment is effective for mature, even-aged stands but may not kill small trees, has become costly, and is limited to rock free soils on relatively smooth, level sites. A mulch of crushed tree left on the ground is visually acceptable.

Bulldozing is effective on small to medium sized junipers in stands of up to 150 trees per acre but is costly and debris and soil disturbance may be excessive. Soil disturbance by mechanical control of junipers may cause weeds and undesirable half shrubs to dominate the sites preventing forage plant establishment or increased production by existing forage plants.

Burning individual trees is effective on nonsprouting junipers but is no longer used because of high fuel costs and the limited times it may be used. Grass fires have killed small junipers in experimental burns but have been used infrequently. Burning juniper stands has been successful but many mature stands do not have enough ground fuel to carry a fire. The main use of fires in juniper control has been to reduce slash left from chaining or bulldozing.

Hand cutting junipers with axes or power saws is effective on small to medium sized, nonsprouting junipers in light density stands but the cost is

high and few workers are willing to do this work for more than a few days at a time. However, fuel wood harvesting has been used to remove large trees. Returns from the sale of cutting permits pay part of the costs of controlling the smaller trees by cutting, bulldozing, or herbicide applications.

Picloram or tebuthiuron control junipers by either individual tree or broadcast applications. Individual tree treatments are suited to trees under 10-feet tall in stands of less than 150 tree per acre. Such stands are on newly invaded areas and reinvaded treated areas. Selective thinning of juniper stands for wood production might also be done this way. Small dead trees cause little visual impact, especially after the foliage has fallen. Broadcast applications are suited to dense stands of all sizes of trees. Dead trees in dense stands can be visually distracting and may have to be removed by burning, crushing, or wood harvesting after establishment of the replacement vegetation.

Safety

The toxicology, degradation, movement, and dissipation of picloram have been reviewed by Mullison (1985) and of tebuthiuron by Elanco (1983). Much research has been done on the characteristics of picloram since 1963 and of tebuthiuron since 1972. All indications are that hazards to the environment, animals, or people are minimal if label directions for these herbicides are followed.

Both herbicides are of low toxicity to animals with no indication of biological magnification. Ingested picloram is rapidly excreted unchanged; ingested tebuthiuron is rapidly metabolized and excreted without accumulating in the body. Picloram is degraded by exposure to sunlight and by soil microorganisms. Tebuthiuron is degraded by soil microorganisms and by growing plants. Both herbicides can be moved by soil water several feet into the soil; however, a high percentage of each herbicide is found within the surface two feet of soil. Both herbicides are lost from the soil most rapidly when plant growth conditions are favorable but may be detected for several years after application. Small amounts of these herbicides may leave an area in surface runoff water, mainly in the initial runoff after application. The herbicides are rapidly diluted to biologically insignificant or nondetectable levels as runoff water passes through untreated areas.

Picloram is a restricted-use herbicide which may be sold only to Certified Applicators because of a concern for possible damage to desirable off-site plants, not because of any danger to animals or people. Tebuthiuron is a general use herbicide and its sales are not limited to Certified Applicators. Both herbicides are registered in Arizona and New Mexico for controlling junipers and pinyons. Various use limitations are listed on the different labels for each herbicide so care must be taken to fully understand and to follow directions on current labels.

Public Acceptance

Since the Agent Orange controversy, some members of the public have been critical of using herbicides, especially on public lands. As this is being written, herbicides have not been used on federal lands in Arizona since early 1984. Arizona is under the jurisdiction of the U.S. District Ninth Circuit Court which has banned any herbicide use on federal lands as a result of a suit about the adequacy of a Worst Case Analysis for spraying 2,4-D on Federal lands in Oregon and parts of Washington. This has not limited herbicide usage on non-federal lands in Arizona and herbicides continue to be used on federal and non-federal lands in New Mexico which is not in the Ninth Circuit Court jurisdiction. Hopefully, public education about herbicides and their careful use by applicators will eventually result in a more favorable attitude towards using herbicides on range and forest lands.

Effectiveness and Selectivity

Effective control of one or more juniper species has been obtained with both picloram and tebuthiuron by individual tree or broadcast applications. Even with delayed responses, especially with tebuthiuron, acceptable control has been obtained. Picloram exposed to sunlight may be decomposed and rendered ineffective. Tebuthiuron is very stable and is not rendered ineffective after application.

Individual tree treatments are selective due to herbicide placement under the tree. Plants adjacent to treated trees may be damaged if their roots are in the treated area or the herbicide is washed off the treated area. Broadcast applications of either picloram or tebuthiuron will damage or kill susceptible non-target plants on the treated areas. Established perennial grasses have not been damaged by picloram at rates recommended to control junipers in the southwest; however, similar rates of tebuthiuron can damage cool season grasses.

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