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Some Ecological Benefits of Woody Plant Control with Herbicides

Productivity of range and pastureland can be increased through use of agricultural chemicals.

Keith C. Barrons

In recent months, several ecologists have expressed concern that the use of herbicides as defoliants in Vietnam (*1*), for the control of undesirable woody plants in pastures, and on right-of-ways might result in soil erosion and soil laterization. These fears would indeed be well founded if the herbicides employed for the control of woody vegetation killed all kinds of plants and kept them from growing. The selective nature of these herbicides has apparently not been fully recognized, and, as a result, the misconception has been advanced that all higher plants disappear after their use.

Those responsible for the extensive application of these materials during the quarter century since 2,4-dichlorophenoxyacetic acid (2,4-D), the first of them, became available fully recognize the tolerance of grasses and some nongrass species. They have seen how grass increases in treated rangeland and pastures as the sprayed weeds and brush die back. They have observed how a sod tends to develop on right-of-ways following treatment. They have further observed that, even where grasses are originally limited in the flora, there is no prolonged soil sterility and tolerant nongrasses soon begin to reestablish and provide soil cover. The need for the subsequent seeding of grasses in some situations where woody growth was very dense, particularly in pasture improvement programs, is well recognized.

Selective herbicides are of tremendous value to agriculture in controlling weeds among, and thereby increasing productivity of, small grains, corn, rice, sorghum, and sugar cane, all members of the grass family. In addition, they are making more animal protein available at a lower cost through improved pastures and rangeland. In forest management, they are useful for site preparation and the selective control of weed trees and shrubs. Apart from being a benefit to crops, their other uses provide easier inspection, better visibility, and increased safety along railroad, public utility, and highway right-of-ways.

The control of unwanted trees, brush, and woody vines with herbicides provides labor economy as compared with cutting, particularly as a result of root and crown kill. The tendency of most woody plants to resprout from underground structures is well recognized by all who have had experience in their removal by mechanical means. Selective chemical control results in far less soil erosion than grubbing or bulldozing and less upset to the ecology in general than fire.

We have an obligation to see that debate on the use of selective herbicides for improving visibility in a theater of war does not hamper continuing use where they can be of great benefit to mankind; however, ecological effects as well as immediate benefits must be understood.

What is the ecological aftermath of woody-plant control with the herbicides 2,4-D (2,4-dicholophenoxyacetic acid), 2,4,5-T (2,4,5-trichlorophenoxyacetic acid), silvex (2,4,5-trichlorophenoxypropionic acid), and Tordon (picloram) (4-amino-3,5,6 trichloropicolinic acid), the major chemicals in current use for this purpose? Obviously, there is need for further studies, but experimentation and commercial use over many years have provided a great deal of information.

Range and Pasture Management

Mitich (*2*) measured the grass and nongrass vegetative growth in a pasture improvement program including plots in 22 counties in North Dakota. After two annual applications of 2.24 kilograms of 2,4-D per hectare, the vegetative cover changed from 67 percent

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Table 1. Result of treatment with Tordon plus 2,4-D.

Treatment	Jaragua grass (ton/acre)*	Other grasses (ton/acre)	Live brush (ton/acre)	Total vegetation (ton/acre)
None	1.80	.28	12.65	14.73
Tordon + 2,4-D	13.55	.29	.50	14.34

* One ton per acre equals 2.72 metric tons per hectare.

grass to 93 percent grass with a corresponding decrease in nongrasses. The average dry weight of all vegetation per plot after 2 years of spraying was 299 grams, compared with 185 grams for the unsprayed plots. Thus, the treatment with 2,4-D resulted in an increase in total growth as well as in the percentage of useful herbage.

At the Gualaca Experiment Station in Panama (*3*) in a zone of annual rainfall of 229 centimeters, the production of grass and nongrass vegetation in a brush-infested pasture of Jaragua grass was measured after treatment with a mixture of Tordon herbicide at 0.672 kilogram plus 2,4-D at 2.688 kilograms per hectare. Cattle were withheld and clippings were made 460 days after application (Table 1). Note the shift from brush to grass in the treated areas with total vegetation remaining essentially constant. Figures 1, 2 and 3 illustrate herbicidal application and end results of this Central American pasture improvement program.

In Colorado, Paulsen and Miller (*4*) sprayed rangeland infested with rabbitbrush and wild geranium with a Tordon herbicide formulation at 2.24 kilograms of active ingredient per hectare. Following the measurement of vegetative growth 1 or 2 years after application, they concluded: "The spray treatments significantly increased grass production, and correspondingly decreased forbs. Total herbaceous production was approximately the same on the treated and the untreated control plots."

Dowler *et al.* (*5*) observed vegetative succession in Puerto Rico after the application to the soil of a number of herbicides. Their observations, made during an 18-month period following application, indicated that "grasses, herbaceous plants, and vines generally were more numerous than were woody tree seedlings." In these tests, Tordon herbicide, the most residual (lasting longest in soil) of those employed, effectively defoliated woody plants on three sites chosen for great variation in rainfall. They found no long-term sterility, even where the herbicide was applied at dosages considerably above those recommended.

In studies of plant successions in the Ozarks following aerial spraying for woody plant control, Davis (*6*) concluded that the vegetation that develops subsequent to a woody plant control program in northwest Arkansas can be expected to be similar to a typi-

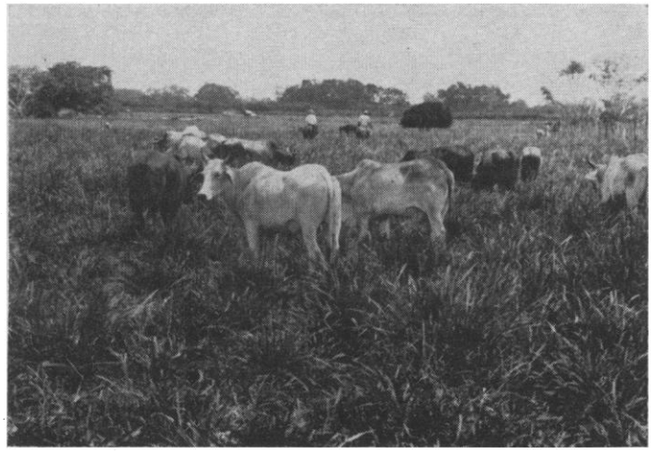

Fig. 1 (above left). Aerial application of a selective herbicide to tropical rangeland brush.

Fig. 2 (above right). Jaragua grass development in Panama after the application of a selective herbicide for woody plant control.

Fig. 3 (bottom left). Cattle grazing a pasture in Panama improved through brush control, seeding, and fertilization.

cal tallgrass prairie. These and many other experiments show that selective herbicides provide chemical tools for inducing grassland development and improvement. The recognized value of grass in soil conservation and soil building is well expressed by Eyre (*7*):

A soil developing beneath grassland is subjected to conditions which are very different from those experienced by a developing forest soil. It has been shown in previous chapters that, beneath much natural forest, most of the organic material which comes to the soil is supplied to an almost bare surface by the process of leaf-fall. A loose, friable and relatively well-aerated layer of material thus accumulates which can only be incorporated into the predominantly mineral horizons beneath by purely mechanical mixing processes. These are caused almost entirely by the activities of the larger members of the soil fauna. The aerial parts of grasses, on the other hand, form a much denser "sod" or "turf" as they die down and accumulate. Furthermore, grasses form a dense rooting network throughout the entire depth of the soil beneath. These die away and decay in an almost continuous process so that humus, in a finely-disseminated form, is actually placed in the soil by the vegetation. This intimate penetration by roots and humus not only ensures deep inherent fertility but also gives the soil a fine crumb structure and perviousness, regardless of differences in original parent-material. Generally speaking, grasses also take up greater quantities of mineral nutrients, particularly calcium, than do forest trees. The humus returned to the soil by grasses is therefore commensurately richer in nutrients. In turn, as the humus decays, the nutrients are released only to be caught up again by the efficient rooting systems. In this way a very rich nutrient cycle is maintained.

Water Conservation

From the standpoint of water conservation and efficiency of utilization, grass usually provides the optimum soil cover. In Oklahoma, Elwell (*8*) reported that measurements made during an 8-year period on the Red Plains Station showed that 45 percent less water ran off annually from good grass on treated land than from an adjacent area of brushland. In these tests, surprisingly large yields of grass and pastures were realized following use of 2,4-D and 2,4,5-T to control hardwood brush. He goes on to say that, where selective herbicides were properly used, the leaves, twigs, and stems of sprayed brush accumulated in a mulch on the soil (*8*).

Grass also provides the most efficient utilization of the rain that falls on range and pastureland. Based on work in the southwestern United States, Allred (*9*) recorded a marked trend toward a greater water requirement per unit of dry matter by woody plants than by pasture grasses. Because of the low acceptability and nutritive value of leaves of most woody plants to sheep and cattle, the return from a limited water supply in terms of meat, milk, and wool are far greater when the available water is utilized to produce grass rather than woody brush.

The increased availability of ground water following control of woody plants has long been recognized by ranchers and watershed management people. The deeper rooting of woody species as compared with grasses and forbs, the better retention of rainfall, and the more efficient utilization of water by grasses are all believed to influence this difference. Following control of *Eucalyptus* in Queensland, Australia, by injection of an herbicide into the conductive tissue, Young (*10*) observed:

The area is steep, broken country drained by short, fast flowing creeks. Beef cattle have been raised in this region now for three generations. It is generally known that most smaller creeks and gullies cease to run in early autumn and by midwinter are useless as a source of stock water. However, these gullies in mid-July, 1968, are still running strongly, yet no exceptionally wet summer was experienced. The height of water in numerous wells has risen almost to the surface, and springs high up near the source of some of the drainage lines are holding water now all the year round. This effect of increased water was first noticed 8 to 12 months after extensive areas of ridges had been treated.

Table 2. Acute oral toxicity of herbicides to warm-blooded animals. Toxicity expressed as LD_{50} in milligrams per kilogram of body weight, the amount administered in a single dose that killed 50 percent of the animals tested.

Herbicide	Toxicity (mg/kg)
2,4-D (*18*)	375
2,4,5-T (*18*)	500
Silvex (*19*)	650
Tordon (*19*)	8200

Industrial and Forest Uses

The labor savings made possible by the use of selective herbicides on right-of-ways for the control of woody species that would endanger powerlines, inhibit visibility, and present other safety hazards have allowed maintenance people to use a greater part of their budgets for providing better roads, railroad beds, and power and pipeline transmission systems. Besides being costly, the old method of repeated hand cutting of right-of-way brush, followed by stacking and burning, often resulted in escaped fires.

In a 15-year study of the ecological aspects of chemical brush control on a utility right-of-way in Pennsylvania, Bramble and Byrnes (*11*) found that a relatively stable community of the original ground cover plants—bracken, sedges, herbs, and blueberry—developed after basal or cut stump treatment with phenoxy herbicides. Broadcast sprays applied to foliage and stems of the unwanted tall-growing woody species modified the ground cover composition; bracken and sedges were maintained but sweet fern replaced blueberry as the dominant low shrub.

Their studies indicated a high incidence of game usage of the treated right-of-way as compared with the adjacent wooded areas which were seriously overbrowsed and nearly bare of low cover and food. Rabbits, grouse, and wild turkeys appeared to benefit from the stable low cover induced by the herbicide treatments. The authors report: "All of the common species of plants composing the dominant plant cover on the right-of-way were used by major game species of the area. All plants except fireweed were used heavily in at least one season by at least one species of game. This gave further indication of the value of plants produced in large qauntities on the right-of-way following chemical brush control."

The establishment of new plantings of forest trees is often made very difficult by the presence of "weed" trees and shrubs that compete with desired tree seedlings for light, water, and mineral nutrients. Site preparation with herbicides prior to planting is proving effective for killing or greatly reducing the growth of these unwanted woody plants (*12*). Selective control of undesirable woody species growing in established forest plantations is an increasingly common practice, carried out by foliar sprays, applied aerially, by basal treatment to the individual weed tree, or by injection into the tree (*12*).

Effect on Other Organisms

In evaluating the overall effects of a given herbicide, one must consider the response of the various types of organisms that could be exposed. The toxicity of these herbicides to warm-blooded animals when given as a single oral dose is indicated in Table 2. Tordon herbicide was found to be very low in toxicity to Japanese quail (*13*). Birds on diets containing up to 1000 parts per million of this compound over a period of 8 to 20 weeks for each of three successive generations showed no variation from the controls in mortality, weight gain, egg production, fertility, and hatchability.

Hardy (*14*), working with the representative food chain organisms *Daphnia*, algae, and a small fish, found no adverse effects of Tordon herbicide at 1 part per million in the water, nor was there a buildup in tissues of these organisms. There was no adverse effect on *Daphnia* which fed on algae grown in water containing 1 part of this herbicide per million nor on the fish which fed on the *Daphnia*. Butler (*15*) found little if any inhibition of phytoplankton (mostly diatoms and dinoflagellates) growing in water containing 1 part of 2,4-D, 2,4,5-T, or Tordon herbicides per million when used as the acids or as salts, the forms in which these compounds are likely to be present in surface-water bodies. Tordon herbicide in water is degraded by sunlight (see *16*).

All of the compounds referred to have been found to be degraded in soil through natural microbiological processes. The most rapidly degraded is 2,4-D, followed by 2,4,5-T, and then by silvex. Tordon herbicide is the most slowly degraded and correspondingly requires the least amount of material for the effective control of nongrass species. The rate of degradation is largely a function of soil temperature, moisture, and organic matter (*17*). Until degradation is complete, small residual amounts of these herbicides that will bring about growth suppression or formative effects on susceptible species usually have no observable effects on established grasses and the more tolerant nongrasses.

As stated on the labels, care must be exercised in application of all of these compounds to avoid spray drift to susceptible plants. Fortunately, improved systems of application are now available which minimize the number of tiny droplets which may become airborne and contact plants some distance away from the sprayed area. As indicated in registered labels, special care must be exercised with these herbicides to avoid contamination of water that ultimately may be used for irrigation purposes.

Looking Ahead

It appears probable that application of selective herbicides for brush control integrated with the release of sterile males of the tsetse fly will make it practical to control this dreaded insect through the vast regions of Africa where it is endemic. Neither livestock nor people have prospects of good health in this part of the world because of the sleeping sickness disease transmitted by the tsetse fly, and only after its control can the area have a meaningful future. The fly must have tree or brush cover for its breeding and survival. Elimination of the insect through woody plant control alone is neither practical nor desirable, but the reduction of woody plant growth over significant areas would greatly reduce the population of the tsetse fly, thus making control with sterile males more practical. The improved grass production resulting from brush control obviously would provide a bonus if cattle-raising operations are developed.

A sizable proportion of the earth's land surface is ill-suited to intensive crop production but if well managed will produced much grass to support ruminant animals. Productivity of pasture and rangeland is often limited by unpalatable, nonnutritious, or poisonous plant growth. Herbicides are useful and proven tools for creating better grassland to produce more meat and milk. Both can be important in overcoming the protein deficiencies that threaten the health of so many people in less-developed countries, and both are vital to a continuation of the high level of nutrition now being enjoyed in the more fortunate parts of the world.

Since he first set a forest fire and first girdled a tree to provide better grazing and land for crop production, man has been faced with the continuing need to control woody vegetation. During the last quarter century, selective herbicides have given him new tools, ones which have certain ecologic as well as economic advantages. Where woody vegetation must be controlled—on range and pastures, in forest tree production, and on right-of-ways—these advantages should be carefully considered.

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