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Bulletin No. 14: Creating New Landscapes with Herbicides, A Homeowner's Guide

William A. Niering
Connecticut College

Richard H. Goodwin
Connecticut College

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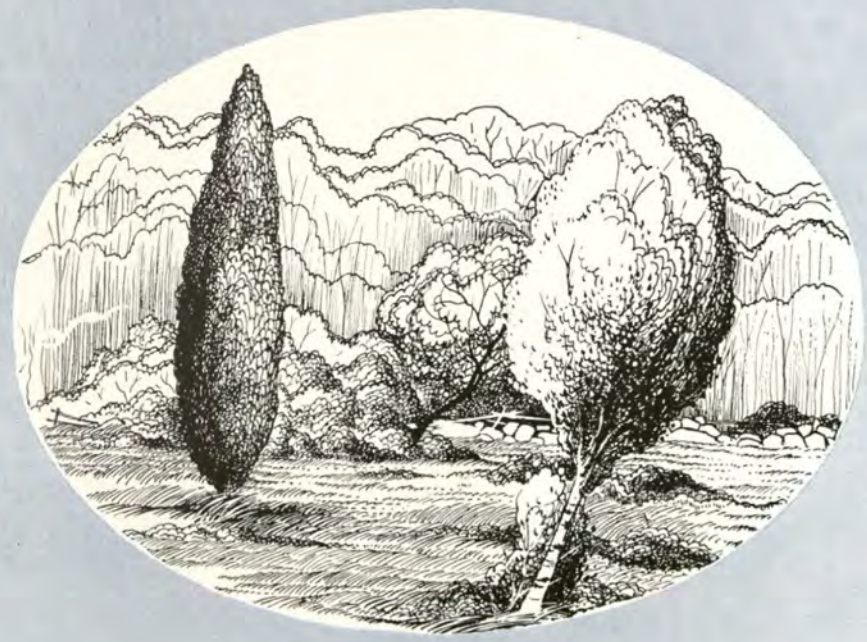

The Connecticut Arboretum
Connecticut College

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Creating New Landscapes With Herbicides

A Homeowner's Guide

William A. Niering
Associate Professor of Botany, Connecticut College

and

Richard H. Goodwin
Professor Botany and Director of the Connecticut Arboretum

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Introduction

IN TODAY'S WORLD, the owner of the small country estate or large suburban lot is frequently faced with a number of special vegetation management problems in shaping the environment to suit his requirements. Thus he may wish to remove certain undesired trees, shrubs, vines or weedy herbs and to encourage other attractive and useful species. He is likely to find himself frustrated by the unavailability of skilled labor or handicapped by inadequate funds to hire such services. The purpose of this bulletin is to serve as a how-to-do-it guide to the use of labor-saving techniques that may help solve some of these problems.

It has only been within the past few years that the discovery of the herbicide, 2,4-D, ushered in a new era in the management of vegetation with chemicals. Herbicides are chemicals that can kill plants. They have the ability, when properly applied, to kill not only the parts of the plant touched by the compound, but more importantly the underground roots and stems, so that even woody plants, if properly treated, will not sprout from the base after they have been cut down. Certain of the herbicides are selective, in that they do not kill such narrow-leaved herbs as the grasses. Thus they offer spectacular opportunities for the easy and economical elimination of unwanted vegetation.

Herbicides are not to be confused with insecticides. The latter are designed to kill insects and many are highly toxic to higher animals, including man. Some of them, such as DDT, are extraordinarily stable and persist in the environment for long periods of time and are passed along in the food chain from one organism to another (3). The hazard to man posed by the careful use of certain of the herbicides, on the other hand, is negligible, if precautions are taken to minimize direct contact with the skin during application. Selective use does not involve the contamination of crop plants, and the compounds are soon broken down in the soil to harmless substances by bacterial action.

How you can use herbicides to landscape and maintain undeveloped land, improve wildlife habitat, manage the woodlot, and weed the lawn are dealt with in the following pages. The recommended techniques, which are described in detail, are largely based upon practical experience and experimental data obtained at the Connecticut Arboretum (9, 10, 11, 12, 13, 14). Limitations of the chemical approach are mentioned and precautions that should be taken are emphasized.

The authors wish to thank Dr. Frank E. Egler and Dr. Betty F. Thomson for their many helpful criticisms of the manuscript and Miss Carol H. Woodward for her editorial assistance. They are indebted to an anonymous donor for a gift to the Arboretum to help defray expenses of publication and to Mr. Louis Darling for the line drawings.

Landscaping With Herbicides

APPROACH TO THE IDEA

ALTHOUGH most sections of the country have certain native plants which tend to beautify the natural landscape, the northeast is especially fortunate in this respect. Here, the early spring flowers of shadbush *(Amelanchier* spp.) are followed by those of flowering dogwood *(Cornus florida)* and the native azaleas *(Rhododendron* spp.). These are succeeded by mountain laurel *(Kalmia latifolia)* and later by the fragrant white blooms of sweet pepper bush *(Clethra alnifolia)*. Fall brings an array of autumn color—fields of goldenrod and asters, or scattered highbush blueberries *(Vaccinium corymbosum)*, now a flaming red, set in a golden grassland. In winter gray birch *(Betula populifolia)* is silhouetted against such evergreens as red cedar *(Juniperus virginiana)*, ground juniper *(J. communis)*, and mountain laurel.

Wild or unused land in various stages of natural revegetation following abandonment from agriculture may possess great charm or may have tremendous aesthetic potential, if skillfully manipulated and maintained. Attractive native species of plants are usually growing spontaneously in such areas and only need encouragement through selective removal of the less desirable species that are crowding them. Here herbicides provide the owner of such real estate with a technique for enhancing and maintaining the beauty of his property with a minimum of effort and expense. This approach to vegetation management has been described by Kenfield (6).

PLANNING THE ATTACK

In order to get the most out of a natural tract of land one should first take an inventory of the native species that are already present, their location, condition and potential size. Some may already be fine specimens and well placed, some may only be seedlings, and still others may be malformed or diseased. With this information in mind, plan the type of effect you wish to achieve—an open meadow dotted with specimen trees and shrubs, a screen from the highway or neighbor's yard, a shrub border at the edge of a woodland, swamp or pond. There are as many possibilities as there are tracts to be landscaped. Often enough attractive and interesting species will already be present, but if not, more can be planted. Our native species are ideally suited to the climate and require minimum care.

Wherever weedy or otherwise undesirable trees, shrubs or vines are present, these plants may be selectively eliminated by appropriate treatments. Trees can be cut down, and the stumps treated with an herbicide to prevent resprouting *(stump treatment)*. Or, if desired, trees can be notched or frilled at the base with an axe and the notches or frills treated *(notch/frill*

treatment). In this case the tree will die standing and can be removed later or allowed to rot and fall, depending upon the circumstances. Shrubs, too, can be cut and stump-treated or the herbicide applied directly to the bases of the stems *(basal treatment)*. Vines, briers and brambles may also be selectively eliminated with the use of chemicals. Details concerning the types of herbicides and methods of application are discussed in detail in a later section of this bulletin.

Whenever it is practical, pulling young plants or seedlings by hand is to be preferred to the chemical approach. Non-sprouting species, such as the majority of the conifers, will obviously not require a chemical application.

If care is exercised, it is possible to eliminate the undesired species with almost no damage to adjacent vegetation. Thus, crowded specimens may be released, vistas opened up, and handsome plants made focal points or given the optimal surroundings for effective display.

SOME SUCCESSFUL PROGRAMS

Dr. Frank E. Egler has naturalistically landscaped about 40 acres on a country estate in western Connecticut, using herbicides to manipulate the native vegetation, and Carol H. Woodward has described the potentialities of this technique as observed there (19). Here fields and thickets, rapidly growing up to woody tangles, have been manipulated by selectively eliminating undesirable species and preserving the attractive ones. The removal of species has been accomplished both by mechanical and chemical techniques. The end result has been the creation of beautiful vistas through open and semi-open fields with scattered native shrubs and low-growing trees as accent points. Non-native plants that can survive and bloom without garden care have been set out. A five-mile net-work of trails is maintained across the landscape and through the adjacent forest by herbicides and mowing.

Where goldenrods, asters, ferns, spreading dogbane *(Apocynum androsaemifolium)*, milkweed *(Asclepias* spp.) and other perennials become overly abundant or detract from the general aspect of the natural grassland, Dr. Egler recommends mechanical and chemical management techniques, often in combination. Actual removal of the unwanted plants by pulling is sometimes the most practical method, if the area is small. Otherwise, cutting, followed by spraying, may be desirable (see p. 23).

At the Connecticut Arboretum two areas have been especially landscaped with herbicides (10). In 1953 a portion of the Katharine Matthies Tract, an old orchard and pasture which had become invaded by a large number of trees and shrubs, was selected for experimental work (see Figure 1). Later a small plot within the cultivated portion of the Arboretum was developed by botany students at Connecticut College. Among the attractive

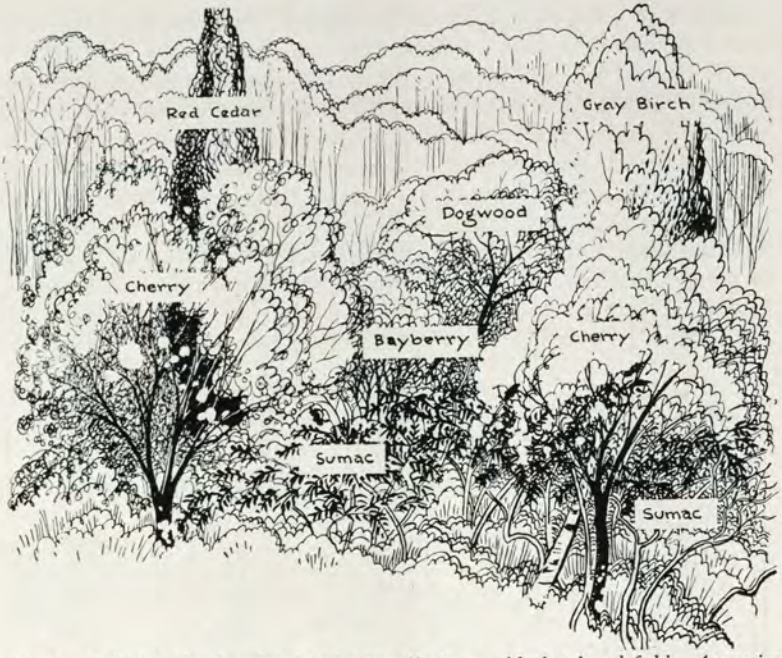
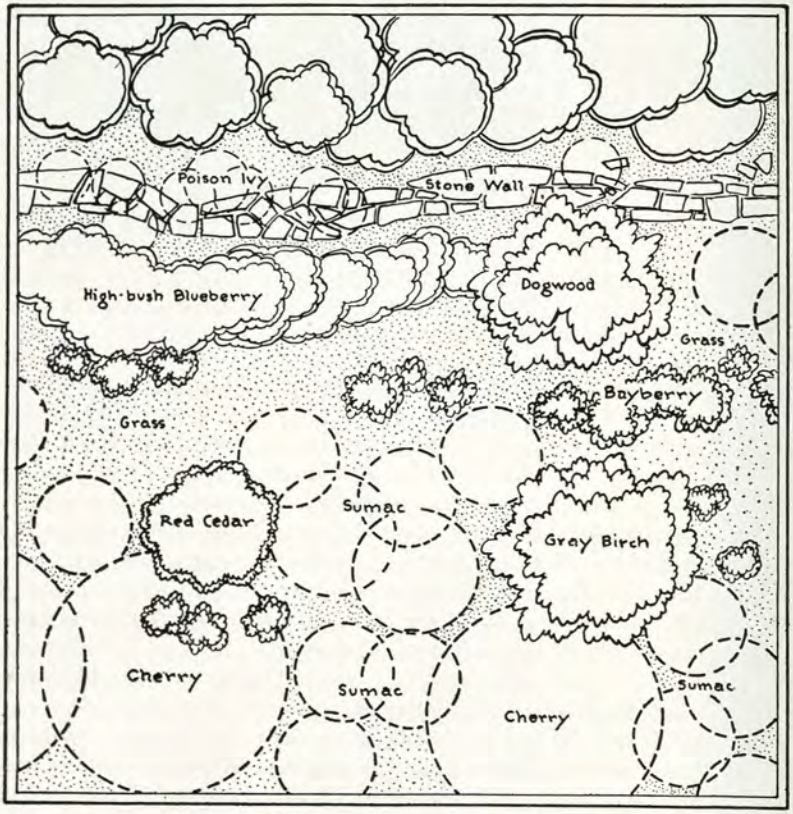


Fig. 1. A thicket that has developed naturally in an old abandoned field. Attractive native trees such as gray birch, red cedar and dogwood are being crowded out by cherry and sumac.

native shrubs and low-growing trees occurring in these areas are wild rose, meadowsweet *(Spiraea latifolia),* chokeberry *(Pyrus arbutifolia),* huckleberry *(Gaylussacia* spp.), highbush blueberry, common barberry *(Berberis vulgaris),* bayberry *(Myrica pensylvanica),* Virginia creeper *(Parthenocissus quinquefolia),* winterberry *(Ilex verticillata),* arrowwood *(Viburnum recognitum),* shadbush, flowering dogwood, gray birch, red cedar, ground juniper and mountain laurel. Localized patches of sumac *(Rhus* spp.) have been retained for their autumn color. Herbaceous perennials of especial interest include the grasses, little bluestem *(Andropogon scoparius)* and redtop *(Festuca rubra),* and broad-leaved perennials such as butterfly weed *(Asclepias tuberosa),* Queen Anne's lace *(Daucus carota),* black-eyed Susan *(Rudbeckia),* daisies, goldenrods, and asters. Less desirable species which have been reduced in abundance or eliminated by means of herbicides are blackberry *(Rubus* spp.), poison ivy *(Rhus radicans),* greenbrier *(Smilax rotundifolia),* and some of the young specimens of tall-growing trees, such as wild black cherry *(Prunus serotina),* oaks and hickories.

After nine years, the thicket on the Matthies Tract has been converted into a perennial meadow of little bluestem, redtop and goldenrod in which clumps of huckleberry, bayberry and sumac, scattered shrubs of highbush blueberry, and low trees such as flowering dogwood, red cedar and gray birch, have been permitted to develop into well-shaped specimens (see Fig. 3). This landscaping has been achieved entirely through the selective use of herbicides. Nothing has been planted, and no cutting tool has been employed. Although some of the larger trees killed by the herbicides were unattractive for a year or two, these decomposed rapidly after they fell to the ground. If an aesthetically pleasing aspect had been desired immediately, the dead standing brush could have been removed with a little additional effort. The immediately adjacent control area is now grown up to an



Fif. 2. A ground plan of the area in Fig. 1. The locations of the trees and shrubs to be eliminated are outlined by broken circles.

unattractive dense growth of sumac, briers, wild cherry and other species of young forest trees.

In the smaller area behind the outdoor theatre, the College students have developed an attractive grassy opening in which winterberry, huckleberry, cedars and dogwood are accents of interest against a background of Arboretum plantings.

MAINTAINING THE EFFECT

What are the problems in maintaining an attractive landscape? In many areas they may be relatively simple. Although semi-open grasslands and thickets are thought to be relatively unstable, tending rapidly to revert to forest, this instability is not necessarily true. The nature of the surrounding vegetation obviously plays an important role. If pioneer species, such as white pine or white ash, which tend to spread into open grassland, are growing adjacent to the fields, seedlings of these species may become a serious problem. However, other species are less successful in rapidly es-

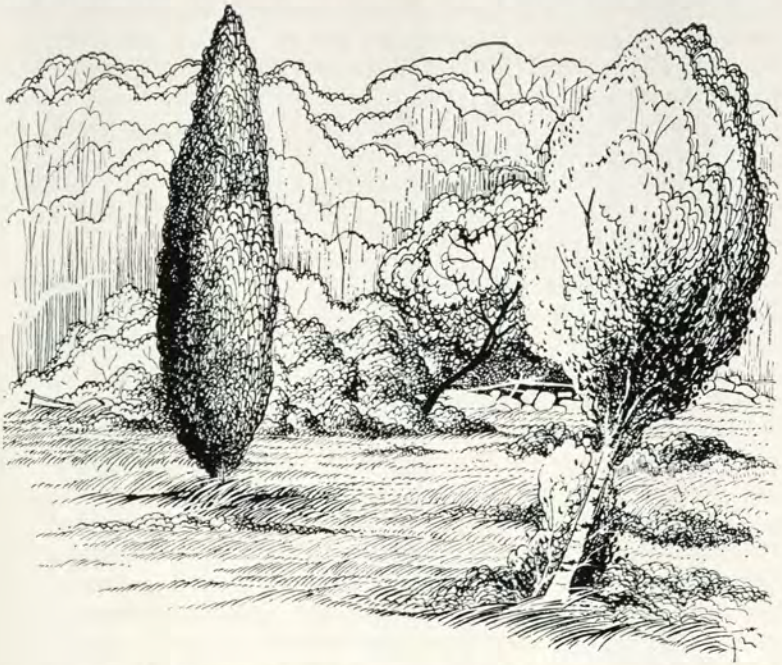


Fig. 3. The view shown in Fig. 1 as it appears after naturalistic landscaping. The attractive species have been freed from competition and have been allowed to develop fully their natural form, thereby enhancing the open area. This effect has been achieved through a selective use of herbicides.

tablishing themselves in a dense grass or goldenrod cover. Trees become established even more slowly in the denser shrubby thickets. The presence of trees in such thickets may often be due to their having become established simultaneously with, or even before, the more rapidly growing shrubs. Our experience indicates that thickets will tend to be relatively stable, whereas the grasslands may require periodic attention. The maintenance required is merely to spot-treat any new trees which invade the area. On the Matthies Tract only sumac, which spreads by an underground root system, is presently in need of attention. The invasion of trees has not become a problem.

Providing Habitats for Wildlife

THE NATURAL VEGETATION can also be manipulated by weed-killers in order to create or maintain various types of wildlife habitat. Different environments, such as dry fields, wet meadows, semi-open fields and thickets, support distinctive types of wildlife. In the northeast, the large open areas favor the meadow lark, bobolink, grasshopper sparrow, bob-white and pheasant, which are dependent upon the seeds and insects characteristic of these habitats; while in the shrubs and thickets the yellowthroat, catbird, chestnut-sided warbler and towhee, along with the cottontail rabbit, are the common species. On abandoned agricultural land there is a tendency toward forest development with eventual shading out of the grassy and shrubby areas. This in turn eliminates the distinctive animals associated with the original open habitat.

A grassland can be maintained by occasional mowing, by selectively spraying the woody species with herbicides as they appear, or by a combination of these methods. If the woody vegetation has already taken over much of the area, more work will be required to restore it to grassland, but this can be achieved by cutting the tree and shrub growth and spraying the stumps (see page 16). If extensive thickets are cleared and sprayed, bare soil areas may result from the oil spray, but these will be revegetated in a year or so.

To maintain the thicket habitat, trees, which would eventually shade out the shrubs, must be removed by basal, notch/frill, or stump techniques (see pages 13-16). Some of the more desirable berry-producing shrubs which should be preserved for wildlife are bayberry, highbush blueberry, sumac, greenbrier, poison ivy, shrubby dogwoods *(Cornus* spp.), viburnums, spicebush *(Lindera benzoin),* blackberries, chokeberries, wild rose, winterberry, huckleberry, elderberry *(Sambucus* spp.), honeysuckles *(Lonicera* spp.) —but not the Japanese honeysuckle *(L. japonica)* !—, and common barberry. Others, producing nuts, include hazelnut *(Corylus* spp.), witch-

hazel *(Hamamelis virginiana)* and scrub oak *(Quercus ilicifolia)*. Low growing or small trees of especial importance are flowering dogwood, red cedar, hawthorn *(Crataegus* spp.) and shadbush.

In the Arboretum, a sizable community of mixed shrubs and low-growing trees is being maintained with weed-killers. The taller-growing trees have been sprayed with the basal or notch/frill techniques and left standing. Scattered larger trees, especially around the edge of the area, have been left to increase habitat diversity.

The sprout growth of certain tree species such as red maple provides excellent winter browse for wildlife. Cutting such trees down without chemical treatment of the stumps serves to open up the canopy while at the same time producing food and shelter. Mr. Richard Brett has found that felling the trees by chopping them on only one side, so as to leave an intact connection between the stump and the trunk, keeps the top alive and thus increases the amount of browse and shelter and the length of time these remain available. Although this technique looks somewhat untidy, it is effective.

Herbicides in Woodlot and Forest

IN THE SMALL WOODLOT or forest plantation, chemicals are useful in eliminating undesired competitive species. They can be used to good advantage in thinning an over-stocked stand where stem density is too great to permit successful development of individual trees. In certain mixed hardwood-conifer stands in the northeast a thinning of the hardwoods may serve to release an understory of white pine. Whether or not this sort of procedure is practical depends first upon local site and soil conditions, which are very important to the quality and growth of the pine stands (8), and second upon the long-range objectives of the land-owner. In some places mere fire protection may be all that is required to permit the pine to develop, although opening the forest canopy may accelerate the growth process.

In Christmas tree or other plantations, competing hardwoods can be readily removed with weed killers. The techniques to be used are essentially those discussed earlier—the basal, notch/frill or stump treatments (see pages 13-16). Usually it is not necessary to cut down competing species, but merely to treat the trunks and leave them standing. At the Arboretum, herbicides have been used in the evergreen plantations to release pine from competing black cherry, and in natural hardwood stands to make an improvement thinning.

The Chemicals and Their Uses

SPECIFIC COMPOUNDS

THE FOLLOWING GROUPS of herbicides have been used successfully at the Connecticut Arboretum: the phenoxy compounds, Ammate and amino-triazole. They are all subject to breakdown by microbial action and hence probably have no cumulative residual effect on the soil or food chain. Arsenical compounds and soil sterilants are not recommended.

The phenoxy compounds, including 2,4-D (2,4-dichlorophenoxyacetic acid) and 2,4,5-T (2,4,5-trichlorophenoxyacetic acid), are among those most widely employed both commercially and by the home-owner. These compounds are available primarily as low-volatile esters—that is, the basic molecule has been combined with another organic compound which makes the herbicide less readily evaporated. They are selective in their killing action, since the grasses are relatively uninjured when they are hit incidentally in the process of spraying undesired species. Water, fuel oil or kerosene may be used as a carrier. If oil or kerosene is used, however, especially in stem-foliage applications, grasses may be killed by the carrier. On broad-leaved herbaceous perennials 2,4-D is more effective, while 2,4,5-T gives a better kill on woody species. Since these two compounds are usually available in various combinations, the specific mixture best suited to produce the desired result should be selected. To eliminate woody growth an herbicide mixture with a relatively high concentration of 2,4,5-T should be selected. Unless otherwise stated, all formulations of 2,4-D and 2,4,5-T are based on reagents containing approximately 4 pounds of acid equivalent per gallon—that is, the reagents should contain four pounds of active portion of the molecule per gallon. A closely related material [2(2,4,5-trichlorophenoxy propionic acid)], marketed as Silvex or Kuron, has been found more effective on hard-to-kill perennial weeds.

All of these compounds, even the "low-volatile esters," are volatile—that is, they give off fumes after spraying, which can be harmful to nearby untreated vegetation. Furthermore, fine droplets of spray may drift in the wind and damage nearby plants. These materials,therefore, are not recommended for use near vegetable and flower gardens.

Ammate (ammonium sulfamate), a water-soluble crystal or powder, is another effective compound. This substance is non-selective in its action, killing both grasses and broad-leaved plants. Its primary advantages over the phenoxy compounds are that it can be applied as crystals with a spoon to cut trunks and stumps and that it is non-volatile and can therefore be used safely as a stem-foliage spray near flower gardens and crops. It is very corrosive to spray equipment, however.

Amino-triazole (3-amino-1,2,4-triazole) or *Amitrol* is a water-soluble

powder used in stem-foliage sprays. It is especially effective on poison ivy and various other difficult-to-kill perennials, including certain grasses. Special care should be taken with this compound to avoid contact with the skin and contamination of fruits and vegetables.

EQUIPMENT REQUIRED

Sprayers of various sizes are available at local hardware or farm equipment stores where the chemicals are also sold. A two-gallon hand sprayer is a good size and easy to handle (Fig. 6). Larger five-gallon back-pack sprayers are also available (Fig. 7). Although a sprayer is desirable, the chemical can be mixed in a can and applied with a paint brush in the case of the basal, notch/frill and stump treatments, or, in the case of Ammate, the dry crystals may be applied to notches or stumps with a spoon. A sprayer is recommended for stem-foliage treatments, but one should use a relatively low pressure in the tank and a nozzle adjusted to deliver a coarse spray in order to minimize drift. A garden water sprinkling can may be used, but selectivity will be limited.

METHODS OF APPLICATION

There are several spray techniques which can be used, depending upon the problem at hand. The technique should be chosen that is most selective, while at the same time giving the best root-kill of the undesired species. For most woody plants the preferred techniques are the basal (Fig. 4), notch/frill (Fig. 5) and stump treatments (Fig. 6). In the *basal* technique the chemical is applied to the bases of standing stems until it runs down and soaks the root collar at the ground level. In the *notch/frill* technique the trunk is soaked especially in the area broken by the notches or frills. In the *stump* technique the stump is soaked to run-down following cutting.

Stem-foliage sprays are applied to the stems and foliage. They are recommended only for multi-stemmed growths of poison ivy, Japanese honeysuckle and other such species, where the previously described methods may not be feasible. The stem-foliage technique is not as effective as the other methods in obtaining root-kill on various tree species, especially the more resistant oaks, hickories and ashes. Often only leaf-burn or stem-kill (kill to the ground), rather than root-kill, results, and retreatment becomes necessary. Furthermore, masses of brown foliage, referred to as "brown-out," although temporary in nature, do not add to the aesthetic appearance of the area treated, and may, in some cases, be detrimental to wildlife habitat. Stem-foliage sprays are recommended for controlling certain broad-leaved herbaceous plants.

PRECAUTIONS

Since the herbicides cannot be readily removed completely from spray equipment, be sure never to use such equipment or containers contaminated with weed-killers for solutions such as fungicides or insecticides that are to be applied to crops, ornamental plants or any other desirable vegetation. Traces of herbicide remain even after repeated washing. Use extreme care in the disposal of any unused solutions. These can kill plants and contaminate ground water. Make up only as much solution as you plan to use.

Direct contact of herbicides with the skin should be avoided (3), but danger to pets and wildlife from a careful and selective use of these chemicals is negligible.

The greatest hazards arise in the use of stem-foliage treatments. Here are some points to remember when using the stem-foliage technique:

1. *NEVER* spray on a windy day. Fine spray particles may drift onto desirable vegetation and cause damage.
2. *AVOID* spraying the phenoxy herbicides near a flower or vegetable garden. Care should also be taken not to mix or spill chemicals near or under ornamental species. Fumes may cause damage.
3. *NEVER* spray the phenoxy herbicides when the temperature is over 85° F. These compounds (even the so-called low volatile esters) are volatile under these conditions (i.e., they evaporate), and considerable damage to plants can occur, often at some distance from the point of application.
4. *NEVER* use stem-foliage applications under or near ornamental species in early spring. The new growth is especially sensitive to the toxic vapors and abnormal leaf and shoot growth or partial killing may result (12).
5. *AVOID* stem-foliage treatments in pastures, since grazing animals are attracted to sprayed plants and are known to have been poisoned by eating treated vegetation (4, 15, 16, 17).

Control of Woody Plants

TECHNIQUES

THE BASAL, notch/frill and stump techniques can all be used on undesirable trees and shrubs. The following descriptions of these techniques give the size of plant and species on which they can be used, the formulation, and the method of application. The control of certain problem species is dealt with in a later section (see pages 16-21). Since the stem-foliage technique is recommended only where the other methods are not feasible, this approach will be discussed only with respect to those species requiring such treatment.

Basal Treatment

This technique involves the application of the chemical mixture to the bark around the base of the stem (see Fig. 4).

Fig. 4. A basal treatment. The lowermost foot of the stems and especially the root collar at the ground line is soaked with the herbicide.

Use: On woody stems up to 2 or 3 inches in diameter. If stems are larger or have a very thick bark the notch/frill technique should be employed. Effective on oaks, maples, hickories, birches, tulip tree, black cherry and other species.

Formulation: 2,4,5-T or combination of 2,4,5-T with 2,4-D in fuel oil or kerosene. Use 1 part of chemical to 20 parts of oil. This is approximately 13 tablespoonfuls to the gallon. A weed-killer with a relatively high proportion of 2,4,5-T is recommended.

Application: Apply to the basal 12 inches of the stems, being sure to soak thoroughly at the ground line around the root collar. On single stems, soaking just the root-collar region at the ground is adequate. Treatment can be applied at any season, but possible damage to other vegetation will be minimized by fall and winter applications. Summer applications are more effective on certain species, especially oak and birch (5). Root-suckering species, such as sassafras, sumac, tree-of-heaven, black locust and aspen, should be treated in late summer.

Fig. 5. The notch/frill treatments. The trunks are notched (left) or frilled (right) with an axe and the notches or frills soaked with herbicide. Instead of a spray, Ammate crystals may be placed directly in the axe cuts.

Notch/Frill Treatment

This is a modification of the basal technique, which involves breaking the bark by scattered axe cuts around the base of the tree (notching) or by a single line of overlapping axe cuts at the base of the tree (frilling) before spraying (see Fig, 5).

Use: May be used on stems of all sizes, but especially recommended on those over three inches in diameter and on those with thick bark. Two notches on either side of smaller stems is usually adequate, whereas frills are recommended on larger stems. This is an effective technique on the species mentioned under the basal method, and is the one used almost exclusively at the Arboretum.

Formulation: With the phenoxy compounds use the same formulation as for the basal technique. With Ammate, use 1 teaspoonful of crystals for each inch of tree diameter measured 4.5 feet above the ground.

Fig. 6. A stump treatment. The bark of the stump is soaked with herbicide. If Ammate crystals are used, place them directly on the cut surface of the stump.

Application: If using the phenoxy compounds, soak the notches or frills thoroughly at the base of the stem. If using Ammate, place the crystals in the notches or frills around the stem.

Stump Treatment

This technique involves treating the stumps after cutting (see Fig. 6).

Use: Recommended where it is necessary or desirable to remove the standing woody stems.

Formulation: Use the same compounds and formulations as for the notch/frill technique.

Application: With the phenoxy compounds, soak the sides of the stumps thoroughly until the solution starts running down to the root collar. It is preferable to treat stumps immediately after cutting. If stumps have been cut for several months, axe cuts near the ground line just prior to application will increase the effectiveness of the treatment. With Ammate, place crystals on top of the cut stump, one tablespoonful for each three inches of diameter. The use of dry crystals requires no special equipment and is therefore an extremely convenient technique when only a small number of plants is involved.

OBSERVABLE RESULTS AND POSSIBLE RE-TREATMENTS

The first noticeable effects from the basal bark and notch/frill treatments applied during the dormant season may be detected in the spring either by the failure of the plant to leaf out or, if leafing out occurs, by the stunting or death of the stems and foliage during the summer. Root-kill may occur within a few months, or may take an even longer period. Treatments during the growing season result in premature autumn coloration. Following the stump treatment the absence of new shoots or resurge after at least one growing season is fairly good evidence that root-kill has been accomplished. Whenever resurge occurs after any of these treatments a re-application may be necessary. If the shoots are small and malformed or show signs of dying they may be left for another season. If vigorous resurge is evident, re-treat with one part of the phenoxy compounds to 50 parts of oil (approximately 5 tablespoonfuls per gallon) after notching or frilling near the ground line.

SOME PROBLEM SPECIES

Considerable experimental work has been carried out in the Arboretum on the control of poison ivy, Japanese honeysuckle, greenbrier, and oriental bittersweet. Those methods which have proven most successful are outlined. Formulations that have proved effective at the Arboretum for root-sucker-

ing species and for white ash, a species which is reportedly difficult to root-kill, are also given.

Poison Ivy (Rhus radicans)

At the Arboretum various chemicals, including Ammate, mixtures of the phenoxy esters, Kuron, and amino-triazole, have been used. Ammate was effective, but was extremely corrosive to spray equipment. The effectiveness of aqueous sprays of the phenoxy esters (1:100) was increased by the addition of oil to a water carrier or by increasing the concentration of the chemical. Kuron was very effective (1:50 aqueous). Where drift and volatility may be a problem in certain situations around desirable trees and shrubs, amino-triazole has proved to be another excellent material. Since the growth habit of poison ivy varies from diffuse scattered stems to dense woody growths, various techniques are recommended for its eradication. When the growth is extremely dense, such as often occurs on old stone walls, and little or no desirable vegetation is associated with it, a stem spray of the phenoxy-compounds in oil is recommended. For large stems attached to trees, cutting the stem at the base of the tree and treating the cut stubs is satisfactory. If this is not feasible, a stem-foliage treatment with amino-triazole applied with caution to the ivy foliage and stems on the tree trunk will not harm larger trees. Stem-foliage applications are especially useful on scattered growths of poison ivy in grassy or other herbaceous cover.

It should be remembered that poison ivy is valuable to wildlife as a source of food and shelter and should therefore be preserved in situations where these qualities are of primary importance.

STEM OR STUMP SPRAY:

Use: On dense growths of poison ivy, where desirable vegetation is absent, or on large stubs cut off near the ground line.

Formulation: Phenoxy compounds, the same formulations recommended for the basal treatment (see p. 14).

Application: Soak stems thoroughly at any season. Although spring treatments are especially effective, volatility effects can be a hazard if desirable species are nearby. In the case of single stems growing on trees, cut near the ground line and soak top and sides of the cut stump. Be careful not to soak the soil around the tree.

Results: Excellent root-kill. If done in the dormant season, the foliage usually fails to appear in the spring.

STEM-FOLIAGE SPRAY: Only two formulations are given below, although others have proved satisfactory (see p. 27).

Formulation. #1: Amino-triazole. Follow directions of the manufacturer, since the concentration of materials varies depending upon the company. One heaping tablespoon of Weedazol or Amino-triazole weed-killer (50% active ingredients) per gallon of water was used in many Arboretum plots.

Application: Soak stems and foliage thoroughly during the growing season. Respray any new shoots which appear. Early fall treatments, when the foliage is turning yellow, are not recommended.

Results: Foliage turns brown and any new growth which may appear is whitish (i.e., lack chlorophyll). Herbaceous and other shrubby growth covered by the spray is similarly affected. This treatment has been most effective on diffuse growths of poison ivy in the grass along our trails. Slight injury occurred to some herbaceous plants, but tall grass cover predominated after two growing seasons. Wild geranium has flowered in areas sprayed the previous year. Virginia creeper is relatively resistant and appears to be replacing the poison ivy in certain sprayed areas.

Formulation #2: 2,4,5-T and 2,4-D [1 part of chemical to 50 parts of water (5 tablespoonfuls per gallon)]. Use weed-killer with a high proportion of 2,4,5-T.

Application: Soak stems and foliage completely to the ground line during the growing season.

Results: Browning of the foliage occurs. If no resurge results after one or two growing seasons, root-kill has been achieved. Resurge should be resprayed.

Japanese honeysuckle (Lonicera japonica)

Although often planted as an ornamental ground cover, this vigorous, semi-evergreen vine, originally introduced from the Orient, becomes an aggressive weed forming such dense tangles that it completely smothers native herbaceous plants and strangles desirable trees and shrubs. At the Arboretum this vine has been a serious pest around the woody plant collections. Various formulations of 2,4-D have proved relatively satisfactory. Stem-foliage sprays are hazardous, however, whenever desirable species are nearby. Amino-triazole has proved to be most effective when applied in late summer. Two formulations are given—an oil stem spray for application during the winter, and a stem-foliage spray for late summer. For further details on *Lonicera* control see page 28.

STEM SPRAY:

Formulation: 2,4-D [1 part of chemical to 20 parts of fuel oil (13 tablespoonfuls per gallon)]. A mixture of equal parts of fuel oil and water has been substituted for fuel oil with good results.

Application: Soak stems and any foliage present during the winter or spring. If applied in spring be careful of volatility effects. DO NOT USE where desirable vegetation is closely associated. If oil-water carrier is used, shake the tank frequently while spraying.

Results: Root-kill is most effective where the soil is bare beneath the vine cover. Leaf litter apparently protects the bulbous root collar areas from the chemical, and resurge is frequent.

STEM-FOLIAGE SPRAY:

Formulation: Amino-triazole aqueous spray, following recommendations of the manufacturer. One heaping tablespoonful per gallon of water has been used in Arboretum plots.

Application: Soak stems and foliage very thoroughly to the ground during late summer (August or September).

Results: Excellent root-kill where growth is dense and soil is bare beneath. In areas covered with leaf litter more resurge can be expected and re-spraying may be necessary. Better root-kill has been obtained in the more open sites than in the shaded ones.

Oriental bittersweet (Celastrus orbiculatus)

In the Arboretum this introduced ornamental vine has become a serious pest. It twines around desirable plants, eventually killing them by girdling.

Fig. 7. A five-gallon back-pack sprayer of the type used by the U. S. Forest Service.

It is difficult to eradiate because it will regenerate from bits of root left in the soil. The seeds are carried by birds, and seedlings become quickly established under trees and shrubs where the soil is relatively bare. This species is resistant to amino-triazole but has been root-killed with phenoxy compounds in a summer basal spray. On dense growth that has already entangled desirable trees or shrubs, the removal of the vine from specimens prior to spraying the stubs is recommended.

STEM-FOLIAGE SPRAY:

Formulation: 2,4-D and 2,4,5-T [one part of chemical to 50 parts of water (5 tablespoonfuls per gallon.)]

Application: Soak stems and foliage thoroughly to the ground line during midsummer (July).

Results: Root-kill appears best in open areas and where soil is exposed. If the growth is very dense and vigorous or if the area sprayed is shaded and the ground covered with leaf litter, retreatment may be necessary.

Greenbrier and Sawbrier (Smilax rotundifolia and S. glauca)

In southern Connecticut these two briers tend to form impenetrable thickets in open areas. Extensive experimental work has been carried out on the Arboretum's right-of-way demonstration area. These species can be sprayed in the winter with a stem application or during the growing season with a stem-foliage application using an oil-water carrier and a high concentration of the chemical. Of the two species, sawbrier, with its whitish waxy leaves and stems, is the more difficult one to root-kill.

DORMANT STEM SPRAY:

Formulation: 2,4-D and 2,4,5-T [1 part chemical to 20 parts of fuel oil (13 tablespoonfuls per gallon)].

Application: Soak stems to the ground line during the dormant season.

Results: Over 95% root-kill on greenbrier in plots where original cover was continuous and 3 to 5 feet in height.

STEM-FOLIAGE SPRAY:

Formulation: 2,4-D and 2,4,5-T in oil-water carrier (1 part of chemical to 5 parts fuel oil and 15 parts water).

Application: Soak stems and foliage during the growing season.

Results: Over 95% root-kill when applied in July. This is a most effective stem-foliage treatment.

White Ash (Fraxinus americana)

Because white ash is resistant to basal sprays, experiments have been carried out at the Arboretum to determine what techniques might give better

root-kill. Ash saplings and sprout growth ranging from 5 to 12 feet in height have been killed with no resurge appearing for over two growing seasons. Notching or frilling the stems at the ground line prior to spraying greatly facilitates root-kill.

Formulation: 2,4-D and 2,4,5-T (1 part chemical to 20 parts of fuel oil).

Application: Frill or notch at the ground line and then soak the cuts thoroughly with the spray. Spring (April) treatment was effective in the Arboretum plots.

Results: On those trees notched or frilled 90% root-kill was obtained; on stems not cut prior to spraying there was only 20% root-kill. Only the smaller ash trees were root-killed without breaking the bark.

Root Suckering Species

Among the root-suckering species are sassafras, black locust, tree-of-heaven, aspen, sumac and blackberry. Once established, these species reproduce vegetatively by sending up suckers from spreading underground root systems. Basal applications during the dormant season tend to stimulate suckering, and considerable resurge is likely to result from stem-foliage applications unless the stems are thoroughly covered. Late summer applications are most effective. At this season, there is apparently considerable downward movement of the chemical into the spreading root systems. Recommended treatment:

Formulation: Same as for the basal treatment (see page 14).

Application: Use basal or notch/frill techniques. Soak stem bases and root collar areas. Apply in late summer. For dense blackberry thickets, cut to the ground and soak the stubs and soil.

Control of Herbaceous Plants

ANNUALS

Crabgrass and ragweed are annual weeds frequently of concern to the home-owner. The former may be a problem in the lawn and the latter, on recently disturbed soil. A program to control these plants is best based upon an understanding of their life histories and ecology. Annuals tend to become established each year on bare soil, where competition from other species is at a minimum. As perennials cover these exposed sites, the annuals are crowded out.

Crabgrass (Digitaria spp.)

Crabgrass germinates in the late spring. The young seedlings require light, mineral nutrients and moisture, and hence their growth is encouraged

by close mowing, fertilizing and frequent light waterings in May and June. Practices designed to establish and maintain a dense perennial turf are the most desirable techniques for controlling this weed. New lawns should be started in the fall, and fall fertilizing, high mowing and occasional thorough waterings are recommended procedures.

Spring applications of pre-emergence herbicides may be used to kill crabgrass in the early stages of germination and growth. Zytron (O-2,4-dichlorophenyl-O-methyl-isopropylphosphoramidothioate) and Dacthal (dimethyl tetrachloro-teraphthalate) at 15 lbs. per acre have given better than 95% control (1,2). These compounds are reported to be much less toxic to humans and other animals than are arsenicals, the use of which is not recommended.

Ragweed (Ambrosia artemisiifolia and A. trifida)

Around the well-cared-for home grounds, ragweed is not a problem. It thrives on the newly exposed soil where a good perennial cover has not yet become well established. The best control for ragweed is sound cultural practice. On the newly graded slope, the fallow field or vacant lot the establishment of perennials should be encouraged by allowing natural plant succession to occur. Under normal conditions, perennials will shade out or eliminate annuals, such as ragweed, within a year or two. This process can be accelerated by fertilizing and by actually planting perennials. This biological control is recommended by two authorities on ragweed, Dr. Roger Wodehouse (18) and Dr. Frank E. Egler. The reason spraying is not advisable in most situations is that the herbicide not only kills the ragweed, but may also kill or damage the young, broad-leaved perennials just getting established beneath the ragweed. Opening the site or baring the soil by spraying merely encourages another crop of ragweed the following year.

PERENNIALS

These plants, in contrast to annuals, live from year to year, dying down to the ground in the fall, but often over-wintering in the rosette stage and forming buds at or beneath the ground line. They are deep-rooted compared to annuals and are, therefore, more difficult to control by cultural practices.

Perennials in the Lawn

Because of its selectivity, 2,4-D is the most commonly used chemical in the control of broad-leaved weeds in turf. The weedy areas can be treated with an aqueous mixture of 2,4-D or the weed killer can be obtained in combination with fertilizer and applied as a powder. Special tools are available to facilitate the spot treatment of individual plants. These can be filled

with the chemical which may then be applied to deep-rooted perennials such as dandelion and plantain.

The aqueous sprays recommended below are based on the work of Montgomery and Switzer (7). For such species as the docks, prostrate knotweed, shepherd's purse, stonecrop, round-leaved mallow, thyme-leaved speedwell, creeping buttercup, the plantains, bindweed, dandelion, fall-dandelion, silvery cinquefoil, ox-eye daisy and daisy fleabane, 2,4-D amine or low volatile ester [1 part chemical to 500 parts water (1.5 teaspoonfuls per gallon)], may be sprayed on the plants when they are growing rapidly. For hard-to-kill weeds such as black medick, mouseear chickweed, common chickweed, ground ivy, heal-all, corn speedwell and sandwort, use one part Silvex to 640 parts water.

Perennials in other Situations

In neglected or uncultivated areas it may become desirable to eliminate certain well established perennials such as spreading dogbane, milkweed, goldenrods, asters, and the sensitive, hay-scented and bracken ferns. Two formulations are recommended for their control. The first is 2,4-D or 2,4,5-T in water (one part of chemical to 20 parts of water). The plants are soaked thoroughly during the growing season, and the treatment repeated if regrowth occurs. The second, based on the research of Dr. Frank E. Egler in western New England, is 2,4-D and 2,4,5-T in oil (one part chemical to from 20 to 50 parts oil). In this case the treatments are started in the spring with light coverage and repeated throughout the season as new growth occurs. These treatments produce leaf burns, which eventually exhaust the root systems and result in root kill. Extreme caution must be exercised with this spray, since the oil will kill the grasses if improperly applied. Amino-triazole and Silvex have been found especially effective on milkweed and Canada thistle.

Experimental Results With Herbicides

HERBICIDES have been used at the Connecticut Arboretum on an experimental basis and as a practical solution to certain vegetation management problems for over fifteen years. These compounds have proved very useful for weed control in the tree and shrub collections and in removing undesired trees in the forest plantations. More recently we have been developing demonstration areas where the vegetation is being managed by herbicide techniques. These areas include a power-line right-of-way, a town roadside and two landscaped areas. In the following section an attempt has been made to summarize some of our experimental results.

In general, we have found the basal, notch-frill and stump treatments

Table 1. *Basal treatments*

Formulation	*Time of Treatment*	*Species*	*Root-kill*	*Remarks*
2,4-D & 2,4,5-T in fuel oil (1:20)	Winter	Black, Scarlet and Red Oaks	99%	Sprouts 4 to 6 ft. tall
		White Oak	53%	
		Black Birch	98%	
		Greenbrier	Good	
2,4,5-T in fuel oil (1:20)	Winter or Summer	Black Cherry Red Maple Hickory	Good	
2,4,5-T in kerosene (1:20)	August	Black Cherry	Good	Trees up to 5 in. diam. and 12 to 15 ft. tall
2,4,5,-T in 1 oil: 1 water (1:20)	February	White Oak	Poor	
		Black Oak Gray Birch Black Birch Tulip Tree Hickory	Good	
		Greenbrier	Good	Re-treat. needed after 4 years
2,4,5,-T in 1 oil: 8 water (1:20) *or* 2,4,5-T in water (1:20)	August	Black Birch Yellow Birch Hickory Black Oak Ironwood Red Maple	Good	Sprouts up to 10 ft. tall
		Greenbrier	Good	
		Sawbrier	Fair	Considerable resurge

(see pages 13-16) more effective, more selective, and safer to use than stem-foliage applications, wherever trees and shrubs are to be eliminated. They avoid unsightly brown-outs and, when winter applications are practicable, eliminate damage to desirable plants due to drift or volatility. The stem-foliage technique is recommended chiefly for the control of vines, such as poison ivy and Japanese honeysuckle, where the foliage of these plants is required to reveal their presence, and for the elimination of broad-leaved perennials.

Basal Treatment

Since 1953 the basal technique (see page 13) has been used extensively on the Connecticut Arboretum Right-of-Way Demonstration Area. Unless otherwise stated, stems treated are three inches or less in diameter. Excellent root-kill has been obtained on most tree species at all seasons of the year. For root-suckering species, however, late summer applications have proved most successful (see page 21).

Less sprouting of black cherry has been observed after summer than after winter treatments, and Hackett (5) has reported similar results with oak and birch. Excellent root-kill has been obtained with black birch, black cherry, red maple, and hickory when the spray has been applied either winter or summer by merely soaking the root collar at the ground line. In other cases the stems have been covered up to a height of one foot above the ground. Although the various oaks—red, black, scarlet and white—can all be root-killed, white oak has proved to be the most resistant.

Excellent root-kill of dense stands of greenbrier and of interspersed sprout growth of a number of tree species has been obtained, and the application was sufficiently selective to preserve the mountain laurel in the same area.

The results of specific treatments are summarized in Table 1.

Notch/Frill Treatment

The notch/frill treatment is being used at the Arboretum on stems more than three inches in diameter. Both Ammate and the phenoxy compounds have proven effective. Black birches up to three inches in diameter have been root-killed with Ammate crystals applied in notches (2 notches, 1 teaspoonful per notch) in January. Similar treatments on larger birches have been less effective, presumably because of insufficient chemical. Black cherry up to six inches in diameter has been notched and treated with Ammate crystals in December with good results. A supersaturated solution of Ammate painted on the notches was less effective than crystals. The results of Ammate applications to cherry during the growing season were erratic; some trees were root-killed, while others of similar size were not.

Late summer applications of Ammate to tree-of-heaven specimens up to ten inches in diameter have been successful.

The phenoxy compounds in oil have given excellent root-kill. Success has been achieved with the following treatments: 2,4,5-T in oil (1:30) in March on aspen, black birch, red maple and red oak up to eight inches in diameter; 2,4,5-T in oil (1:20) in winter on sprout clumps of black cherry with trunks up to five inches in diameter; Kuron in oil (1:20) in October on black locust up to four inches in diameter.

Stump Treatment

In various sections of the Arboretum it has been necessary to remove larger trees such as cherry, white ash and tree-of-heaven. After cutting, the stumps have been treated in the winter with Ammate—a heaping tablespoonful on stumps over six inches in diameter and a heaping teaspoonful on those less than six inches. Good root-kill has been obtained on cherry and ash, but considerable resurge has occurred on the tree-of-heaven, thus necessitating retreatment. The phenoxy compounds in oil (1:20) have been effective on most woody species when applied at any time of year, but resurge has occurred on root-suckering species after winter treatments.

Stem-foliage Treatment

Stem-foliage applications have been used extensively on poison ivy, Japanese honeysuckle and Oriental bittersweet around the native tree and shrub collections, where they have proved to be a practical and effective approach.

They have also been used on experimental plots along the Right-of-Way Demonstration Area to determine their effectiveness on tree and shrub growth. On trees, root-kill has been highly variable. Certain species such as black and gray birch are very susceptible; others, including black cherry, oak, hickory and especially ash are quite resistant, requiring re-treatment.

One of the basic problems in achieving root-kill on trees is thorough stem coverage with an adequate concentration of the herbicide. Good stem coverage increases the percentage of root-kill, especially among the more resistant species.

Stem-foliage treatment applied in September to sprout growth four to five feet high on sections of the Right-of-Way Demonstration Area by a commercial operator, using 2,4-D and 2,4,5-T in water (1:100) resulted in an average root-kill of 53%. Certain species, such as black oak, black birch and aspen, were more than 75% root-killed; whereas white oak was only 13% root-killed. On an adjacent plot, basally treated in the winter, the black oaks and birches were 98% root-killed, while the white oak, though still resistant, was 53% root-killed. No aspen was present in the basally treated plot.

Commercial applications of 2,4,5-T in water (1:100) resulted in good root-kill of birches. Cherry, oak, hickory and ash were more resistant and showed considerable resurge. Red maple is rather resistant to stem-foliage sprays. Trees of this species up to ten feet in height were effectively killed by doubling the concentration of the herbicide (1:50), a formulation currently recommended by certain chemical manufacturers.

Poison Ivy (Rhus radicans)

Ammate, amino-triazole, the 2,4,D and 2,4,5-T esters, 2,4,5-T and Kuron have been applied as stem-foliage sprays to poison ivy. Results with Ammate have been only fairly successful, with the best control in the more shaded situations. Re-treatments were needed in many plots.

Since drift and volatility effects were frequently a problem with the phenoxy compounds, where poison ivy occurred around the native tree and shrub collections, the effectiveness of amino-triazole has been tested. A single application of one tablespoonful per gallon of water in 1958 gave excellent root-kill on diffuse or continuous low growths in grassy cover along the trails. After four years, less than 5% cover of poison ivy is evident along these trails. Heavy woody growths have also been effectively controlled, but re-treatment has been necessary in certain situations. Late summer application, after the leaves had turned yellow, resulted in partial stem kill but ineffective root-kill.

Virginia creeper is relatively resistant to amino-triazole, and in areas sprayed with this chemical during August 1961, it leafed out the following June, although the foliage was somewhat chlorotic and reddish in color. In some areas an excellent cover of this vine has already replaced the poison ivy. Wild geraniums are also blooming within the 1961 sprayed plots.

Applications of 2,4-D and 2,4,5-T in water (1:100) usually required re-treatments. Where the woody growth was exposed, so that the chemical covered considerable portions of the stems, root-kill was improved. Kuron (1:100) applied in August was very effective on poison ivy growth six inches high. The addition of oil to the water carrier and increased concentrations of the chemical resulted in better root-kill. Using the combined esters (1:50) in an oil-water carrier (1 gallon of oil to 3 or 4 gallons of water), less than 5% resurge occurred after two years. The use of the 2,4,5-T amine in an oil-water carrier (one part oil to one part water) (1:50) resulted in excellent root-kill, especially in the more shaded situations.

On large, vigorous woody growths of poison ivy excellent root-kill was obtained with spring applications of the combined esters or of 2,4,5-T alone, in oil (1:20), when the stems were thoroughly covered.

Japanese honeysuckle (Lonicera japonica)

On this aggressive honeysuckle vine amino-triazole, the phenoxy esters, and mixtures of these compounds have been used with success. In general, treatments have been less successful in shady situations than in direct sun and where leaf litter has protected the older woody stems, which are near the soil surface, from contact with the herbicide. When resurge occurs, re-treatments are necessary. Table 2 summarizes our results.

TABLE 2. *Results of herbicide treatments on Japanese honeysuckle (Lonicera japonica) evaluated after two growing seasons.*

Active Ingredients	*Ratio to carrier*	*Tablespoons per gal.*	*Carrier*	*Time of Treat.*	*Root-Kill*
Amino-triazole[1]	1/260	1	Water	Aug.	Good
Amino-triazole[1] and Kuron	1/260 1/50	1 5	Water	Sept.	95%
Amino-triazole[1] and 2,4-D	1/170 1/100	1.5 2.5	Water	Aug.	Good
2,4-D (Weedone)	1/100	2.5	Water[2]	April	95%
2,4-D (Weedone LV)	1/100	2.5	1 oil:60 water[2]	April	Good
2,4-D amine (duPont)	1/75	4	Water[2]	April	Poor
2,4-D amine (duPont)	1/75	4	1 oil: 150 water[2]	April	99%
2,4-D amine (duPont)	1/100	2.5	1 oil: 150 water[2]	April	Poor
2,4-D ester	1/100	2.5	Water	April	Good
2,4-D (Weedone)	1/20	13	Oil[2]	Jan.	Good
2,4-D (Weedone)	1/30	9	1 oil: 1 water	Jan.	95%
2,4-D and 2,4,5-T	1/7	37	Kerosene	May[3]	Good
2,4-D and 2,4,5-T	1/20	13	Oil	April	95%
2,4,5-T (Esteron)	1/100	2.5	Water[2]	April	Poor

[1] 50% active ingredients.

[2] A sticker (wetting agent) added.

[3] Damage to the foliage of adjacent trees was observed.

Other Species

Sumac *(Rhus copallina)* three to five feet high has been controlled with a late summer basal treatment. A stem-foliage treatment with Kuron in an oil-water carrier (1 qt. of oil to 4 gallons of water) (1:100) applied in late July on sucker growth 12 to 18 inches high following cutting shows

evidence of good root-kill after one season. This was a relatively recently established stand. Older, larger stems are more effectively treated basally. If stem-foliage applications are used in late summer, stem coverage is as important as spraying the foliage.

Tree-of-heaven *(Ailanthus altissima)* has been treated with the notch/frill technique at various seasons other than late summer with good stem-kill on trees up to five inches in diameter, but there has been occasional suckering or healing over of axe cuts on large trees when treated in July. Ammate and the phenoxy compounds in notches or frills have both proved effective. For smaller suckers cutting and treating with Ammate has been successful, although some re-treatment has been necessary.

Blackberry *(Rubus* spp.). Dense clones of blackberry have been controlled by cutting and spraying cut stubs with 2,4,5-T or a mixture of 2,4-D and 2,4,5-T in oil (1:20). Although associated vegetation has been killed by the oil, herbaceous cover has appeared the following season.

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Literature Cited

1. AHRENS, J. F., AND A. R. OLSON. Prevention and control of crabgrass in lawns. Conn. Agr. Exp. Sta. Bull. No. 642. 1961.
2. AHRENS, J. F., R. J. LUKENS. AND A. R. OLSON. Control of crabgrass and other weeds in turf. Conn. Agr. Exp. Sta. Bull. No. 649. 1962.
3. CARSON, RACHEL. Silent Spring. Houghton Mifflin Co., New York. 1962.
4. CRAWFORD, R. F., AND W. K. KENNEDY. Nitrates in forage crops and silage: benefits, hazards, precautions. N. Y. State Coll. Agric., Cornell Misc. Bull. 37. 1960.
5. HACKETT, D. P. Experiments on the chemical control of hardwoods in northeastern forests. Proc. Northeastern Weed Control Conf., 5:311-319. 1951.
6. KENFIELD, W. G. The wild gardener in the wild landscape. The art of naturalistic landscaping. (In press.)
7. MONTGOMERY, F. H., AND C. M. SWITZER. Weed control in lawns. Ontario Dept. Agr. Publ. No. 529:1-32. 1961.
8. MURISON, W. F. The use of herbicides in forest management. Proc. Northeastern Weed Control Conf., 16:34-40. 1962.
9. NIERING, W. A. Herbicide research at the Connecticut Arboretum. Proc. Northeastern Weed Control Conf., 9:459-462. 1955.
10. NIERING, W. A. Research projects on Herbicides: Practical applications of interest to property owners, sportsmen, foresters, and public utilities. Conn. Arboretum Bull. No. 8:14-17. 1955.
11. NIERING. W. A. The Connecticut Arboretum right-of-way demonstration area progress report. Proc. Northeastern Weed Control Conf., 11:203-208. 1957.
12. NIERING, W. A. A potential danger of broadcast sprays. Conn. Arboretum Bull. No. 11:11-13. 1959.
13. NIERING, W. A. The Connecticut Arboretum right-of-way demonstration area: Its role in commercial application. Proc. Northeastern Weed Control Conf., 15:424-433. 1961.
14. NIERING, W. A. Natural landscaping with herbicides. Proc. Northeastern Weed Control Conf. 15:438-439. 1961.
15. OLSON, O., AND E. J. WHITEHEAD. Nitrate Content of some South Dakota plants. Proc. South Dakota Acad. of Sci. 20:95. 1940.
16. STAHLER, L. M., AND E. J. WHITEHEAD. The effect of 2,4-D on potassium nitrate levels in leaves of sugar beets. Science, 112(2921):749-751. 1950.
17. WILLARD, C. J. Indirect effects of herbicides. Proc. 7th Annual Meeting North Central Weed Control Conf., pp. 110-112. 1950.
18. Wodehouse, R. P. Ecological aspects of allergic plants. Proc. Northeastern Weed Control Conf., 13:26-32. 1959.
19. WOODWARD, C. H. Taming the landscape with herbicides. Horticulture. 29 (10):374-376; 29 (11):414-415. 1951.

Connecticut Arboretum Bulletins

No. 3. A Plant Handbook: Lists of Plants for Specific Landscape Uses. Harriet B. Creighton and Priscilla Pasco. 1940. (Out of print)

No. 4. The Connecticut Arboretum: Its Tenth Anniversary. 1941. $.15

No. 5. The Connecticut Arboretum: Recent Land Acquisitions. 1947. .10

No. 6. Check List of Woody Plants Growing in the Connecticut Arboretum and Guide to the Arboretum. Richard H. Goodwin, Katherine H. Heinig and Kaleb P. Jansson. pp. 32. 1950 .35

No. 7. The Connecticut Arboretum: Its History and the Establishment of the Natural Area. 1952. .15

No. 8. The Connecticut Arboretum: The Mamacoke Acquisition and Our Research Program. 1955. (Out of print)

No. 9. Six points of Especial Botanical Interest in Connecticut. pp. 32. 1956. The areas described are the Barn Island Marshes, the Connecticut Arboretum, the North Haven Sand Plains, Catlins Wood, the Cathedral Pines, and the Bigelow Pond Hemlocks. .40

No. 10. Birds of the Connecticut Arboretum and the Connecticut College Campus, pp. 24, 1958. An annotated list with seasonal records and an account of the breeding bird census program. .40

No. 11. A Roadside Crisis: the Use and Abuse of Herbicides. 1959. A proposed program for use of herbicides on town roads, to avoid present destructive practices. .10

No. 12. Connecticut's Coastal Marshes: A Vanishing Resource. pp. 36. 1961. Testimony of various authorities as to the value of our tidal marshes and a suggested action program. .40

No. 13. What's Happening Along Our Roadsides? 1962. .25

No. 14. Creating New Landscapes With Herbicides. A Home-owner's Guide. 1963. 1.00

ADDENDUM

Since the publication of Bulletin No. 14, Creating New Landscapes with Herbicides in 1963 certain new data have become available on some of the chemicals recommended for home use. Among these are amino-triasole (amitrole) 2,4,5-T*. Laboratory studies using amino-triazole suggest the possibility of it being carcinogentic although the data are inconclusive. Until this issue can be clarified it is recommended that this compound not be used by the homeowner. The widespread use of 2,4,5-T in Viet Nam has highlighted the potential danger of this chemical. Following experiments on rats and mice fed small amounts of 2,4,5-T it has been found that many of the fetuses were stillborn and others deformed. A chemical impurity Dioxin is the toxic substance. In April 1970 the Defense Department suspended use of 2,4,5-T in Viet Nam. In the United States it is still being used by utility companies in right-of-way

vegetation management employing either selective or indiscriminate broadcast applications. The home owner is urged to use other compounds, such as ammate, as well as techniques including cutting and girdling, in habitat manipulation on the home grounds. In no situations should stem-foliar applications of amino-triazole or 2,4,5-T be employed.

* Effects of 2,4,5-T on Man and the Environment, Hearings before the Subcommittee on Energy National Resources and The Environment of the Committee on Commerce, U. S. Senate 91st Congress, Second Session April 7 and 15, Serial 91-60 (U. S. Gov't Printing Office, Washington, D. C. 1970.)

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Connecticut Arboretum
Connecticut College
New London, Connecticut