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DR. ALVIN L. YOUNG

HERBICIDE MANUAL

FOR NONCROPLAND WEEDS

ARMY, TM 5-629
NAVY, NAVFAC MO-314
AIR FORCE, AFM 91-19

DEPARTMENTS OF THE ARMY,
THE NAVY, AND THE AIR FORCE

WASHINGTON, D.C.

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AUGUST 1970

DEPARTMENT OF THE ARMY,
THE NAVY, AND THE AIR FORCE

WASHINGTON, D.C.

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ABSTRACT

Practical instruction is presented regarding the classification, use, and application of herbicides; detailed information regarding specific weed species and site situations; and unique characteristics and properties of specific herbicides suggested for noncropland use.

FOREWORD

Department of Defense policy has determined that objectional plant growth on military lands will be controlled by cultivation, mowing, and/or application of suitable herbicides as adapted to the situation. Herbicides are recognized as valuable materials for the economical control of unwanted vegetation. With the present concern over the impact of pesticides on the environment, it is most important that herbicide selection and application be managed by professional personnel.

This herbicide manual for noncropland weeds was prepared as a handbook for the use of registered herbicides generally satisfactory for weed control situations. It is a revision of Agricultural Handbook No. 269, Herbicide Manual for Noncropland Weeds by R. S. Dunham. The revised edition brings the previous manual up to date.

The changing nature of the subject matter will require timely revision and modification. Recommendations or suggestions for modification, or additional information and instructions that will improve the publication and motivate its use, are invited and should be submitted through appropriate channels to:

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INTRODUCTION

Herbicides and control programs involving their use are subject to annual review by the Subcommittee on Pesticides of the President's Cabinet Committee on the Environment. These reviews are concerned with human health aspects, effects on the ecosystem and conformance of proposed usage to the respective herbicide registrations. They are also reviewed in terms of training of technical personnel, the degree and kind of control proposed, and possible alternative pesticides as related to safety, environmental health, and cost of the total operation.

Cautions as listed on the registered labels must be carefully observed. Where contamination of a potable water supply is possible, only those herbicides approved for use in potable water by the military medical department will be applied. High volatile ester of 2, 4-D is not to be used for improved grounds when drift or volitalization could damage ornamentals or desirable crops.

The manual presents practical information regarding the classification, use, and application of herbicides; detailed information regarding specific problem situations; and unique characteristics and properties of specific herbicides suggested for non-cropland use. Tabular presentation is used wherever possible.

If the weeds to be controlled are known, refer to Table 16 for their reactions to herbicides discussed in the manual. To control a group of weeds, such as aquatics, see Table 15 to determine which herbicide may be used and under what conditions. Reactions of the various ornamentals to herbicides are given in Section 3, paragraph 3.5.

Particular herbicides are frequently recommended for certain situations due to special conditions that are inherent in the treatment or application. These factors should be carefully studied and evaluated before proceeding with a specific treatment.

The actual choice of the herbicide should include a study of the information on the label, including rates, times of application, hazards, and warnings or cautions as stated by the manufacturer of a particular product.

BE SURE TO READ THE LABEL

Section 1. GENERAL INFORMATION

Suppression or eradication of unwanted vegetation on noncropland areas has become a major phase of chemical weed control. Until recent years, mechanical methods were the only effective means of controlling weeds on noncropland, including all vegetation on industrial sites such as lumber yards and similar areas; vegetation along paved highways and railroads; woody plants in grassland such as utility rights-of-way; and weeds in ornamental plantings, turf, and aquatic sites.

A knowledge of factors that influence the effects of herbicides on plants, the mode of action, and particular conditions for application is essential for an effective chemical weed control program. Inappropriate selection of the herbicide, incorrect time, or unsatisfactory conditions of application frequently result in failure or poor control.

Appreciation of the hazards of an herbicide to the operator and handler, and the dangers of toxic materials to livestock, fish and wildlife are important concerns for a successful program. Potential injury to desirable plants or limitations for effective use should also be considered in choosing the herbicide.

1.1 GROWTH HABITS AND REPRODUCTION OF WEEDS. Annuals are plants that mature in one season and are propagated by seed. Foxtail, crabgrass, common ragweed, wild buckwheat, and several mustards are examples. A variation of the true annual is the winter annual, which germinates in the fall, lives over winter, and matures early the next season. Some plants of pennycress, common chickweed, corncockle, shepherds-purse, and yellow-rocket behave as winter annuals. The capacity of individual plants to produce thousands or, in some instances, hundreds of thousands of seeds that may shatter to the ground, provides an enormous source of new plants the following season. Many of these seeds remain viable for years when they are buried in the soil. The prolific production of seed, the buildup of weed-seed populations in the soil, and the length of time seeds remain viable in the soil are nature's way of insuring that annual weeds will be perpetuated. It is these properties of annual weeds that make eradication almost impossible. If the topgrowth is killed before seed is produced, the life cycle of that plant is ended, since it cannot recover. However, the reservoir of seeds in the soil may produce new plants for many years.

Biennials require two seasons to complete the reproduction cycle. Their growth period is longer than that of winter annuals. Since they are propagated by seed only, seedlings can be treated as the seedlings of annuals. Burdock, evening-primrose, common mullein, and yellow goatsbeard are biennials.

Perennials are plants that live more than 2 years. Many have additional means of perpetuation; they are provided with storage organs in the form of stolons (prostrate stems), rhizomes (underground stems), bulbs, crowns, and roots. Supplies of food are laid up in these organs by the plant to feed a new growth the next year. The new shoot comes from a bud and lives on stored food until it becomes established. Unlike the annual plant, the topgrowth of a perennial may be killed and still the plant can live and propagate itself because of its storage organs. To control this vegetative reproduction, the food reserves must be materially reduced or the storage organs destroyed. The food stored by the plant is the excess manufactured by the green leaves and stems over and above what is necessary for growth; therefore, if photosynthesis can be prevented, the buildup of reserves will be curbed. For control of perennials, the new growth is allowed to draw on food reserves until it becomes sufficiently established to manufacture its own food and then the topgrowth is killed. Quackgrass, Canada thistle, johnson grass, buttercup, and nutsedge are perennials.

1.2 CLASSIFICATION OF HERBICIDES. Herbicides are grouped, on the basis of use, into selectives and nonselectives and, on the basis of mode of action, into contact, translocated, sterilant, and preemergence chemicals.

1.2.1 Selective and Nonselective Chemicals. Selective herbicides kill certain weed species without seriously injuring the desirable plants among which they are growing. Those that kill crabgrass or dandelions in a grass sod are examples. The reasons for selectivity in some combinations of weeds and desirable plants are known; in other situations, they are unknown. Crabgrass can be killed in bluegrass sod because it is an annual growing among perennial plants that can recover from spray injury. Why dandelions can be killed in bluegrass sod is not fully known; certain herbicides kill broad-leaved weeds and not grasses, and vice versa.

Nonselectives kill vegetation with little discrimination. Certain species, however, are resistant and some escape. Resistant species are physiologically resistant to the chemical; some escapees are perennials that have part of their root system below treated layers of soil; others are annuals and shallow-rooted perennials that reinfest an area after the chemical has leached below the surface layer.

1.2.2 Contact, Translocated, Soil-Sterilant, and Preemergence Chemicals. Contact herbicides kill tissues that are wetted with the spray. Whether the plant dies or recovers depends on whether it has a protected growing point. Perennials usually have underground buds that will regrow.

Translocated chemicals are absorbed by the leaves and stems or by the roots, and move through the vascular system to leaves, buds, and root tips. When absorbed by the leaves and stems, the chemical is commonly moved with the food materials that were manufactured in the leaves and stems. When absorbed by the roots, it moves in the water-conducting tissue. The growth-regulator type of translocated herbicide is a synthetic compound that behaves like a plant hormone. It accumulates mostly in areas of rapidly dividing cells, upsetting the normal metabolism of the plant and causing death of the cells. Foliar applications of translocated herbicides are of great practical

value, because small amounts are effective and they can be applied in small volumes of water or oil.

A soil-sterilant herbicide makes a soil incapable of supporting higher plant life, but it does not necessarily kill all life in the soil, such as fungi, bacteria, and other micro-organisms. Its toxic effects may remain for only a short time or for years. Residual toxicity depends on: the chemical and its rate of decomposition or leaching, the colloidal and chemical content of the soil, species tolerance, and rate of application.

(1) Herbicides vary in their rate of disappearance from the soil because of volatility, susceptibility to decomposition by soil microorganisms, and solubility. For example, some of the carbamates are volatile at high temperatures and rapidly lose their toxic effect during the summer months. Certain soil micro-organisms effectively decompose 2,4-D. Amitrole is soluble in water and readily leached.

(2) Some herbicides are readily adsorbed by mineral and organic colloids and rendered unavailable or made slowly available for plant absorption. The fertility and pH of a soil are also influencing factors in the persistence or availability of toxic amounts of certain chemicals. For example, monuron and diuron are adsorbed on clay colloid particles so that leaching is difficult. Sodium chlorate is more easily absorbed by plants growing in soil low in nitrates.

(3) Plant species vary widely in tolerance to soil sterilants. Deep-rooted woody plants are generally more tolerant to soil sterilants than succulent, shallow-rooted plants.

(4) Heavy rates of application generally last longer than light rates.

Preemergence herbicides are those applied to the soil before the foliage of the weed appears above the soil surface. With reference to crops, the treatment may be made before planting, at planting, or after planting but before emergence. These herbicides kill by contact, or may be translocated from the point of entry into roots, stems, or leaves. Some inhibit photosynthesis, while others affect growth processes such as cell division and elongation. The amount of residual action in the soil may vary as to length of time.

1.3 HAZARDS OF HANDLING AND APPLICATION. Nearly all herbicides are potentially dangerous in one way or another, but they are not likely to cause injury if used properly and if recommended precautions are observed. Several kinds of dangers are associated with the handling and application of these chemicals, and possible injury is not limited to the operator. Any or all of the following may be affected: operator and handler, livestock, desirable plants, equipment, and fish and wildlife.

The general discussion below applies to classes of herbicides rather than individual chemicals. More specific information is given in Section 15. In addition:

Read the label on each container before using the contents. Follow instructions; heed all cautions and warnings, especially the antidote statement for each chemical used. Store in original labeled containers. Dispose of empty containers by burying them at least 18 inches deep in an isolated area away from water supplies or high water tables.

1.3.1 Operator and Handler. The person who mixes and applies the spray or spreads the dry product could be poisoned from swallowing the herbicide, from skin absorption, or from inhalation. In each case, there is greater danger from the concentrated material than from the diluted spray solution or suspension.

(1) If the concentrated spray is ingested, immediate and appropriate action should be taken, depending on the chemical. In most cases, vomiting should be induced by giving the victim a tablespoon of salt in a glass of warm water. Repeat the treatment until the vomit fluid is clear. Keep the victim quiet and warm until a physician arrives. Do not attempt to give fluids by mouth or to induce vomiting in an unconscious person. With some chemicals, such as endothall, do not induce vomiting, but give the victim large quantities of milk, or whites of eggs beaten in water. Be sure to read the label for each chemical used.

The toxicity of herbicides varies widely. Relative degree of toxicity is indicated in Table 1. The ratings describe the acute (not chronic) lethality of each herbicide when swallowed by laboratory animals. Usually toxicity in the field is less, because seldom is such a dose swallowed or absorbed, and diluted sprays are handled more often than concentrates. Nevertheless, neither chemical concentrates nor diluted sprays should be kept in unlabeled containers, especially not in containers commonly used for potable liquids.

Unfortunately humans do not always react the same as small animals. It is always possible that a human will tolerate a correspondingly larger dose of a given chemical than results with animals would indicate, or vice versa. There is no way to determine accurately whether a lethal dose for man is larger or smaller than the LD_{50} (lethal dose for 50 percent of animals tested) for a laboratory animal. But animal studies are the best guide available.

(2) Absorption by the skin, and irrtation of skin and eyes can usually be prevented. Keep exposure to a minimum. Some individuals are hypersensitive to certain chemicals and have allergic reactions that are impossible to predict without skin tests. For most herbicides, washing hands and face with soap and water after handling is sufficient protection. Prolonged contact is more dangerous than short exposures. For the more readily absorbed chemicals and those that are irritating, wear clean clothing that covers the body. Remove clothing after it has become contaminated with the chemical. Use synthetic rubber gloves. Where splashing may occur, wear goggles. If spray or dust is spilled on the skin, wash thoroughly with soap and water; if in the eyes, flush with plain water and see a doctor.

TABLE 1
Chemical, Physical, and Biological Properties of Herbicides for Noncropland Use

Designation	Chemical	Principal use or action[1]	Acute oral toxicity		Test animal	Acute oral toxicity for 150-lb. man[3]	Dermal toxicity	Commercial formulation
			(LD_{50}) Mg/Kg[2]	Rating				
Acrolein	Acrolein	C;Aq	46	Very high	Rats	3/5 teasp.	High	Water-miscible liquid
AMA	Amine methylarsonate	C					Moderate	
Amitrole	3-amino-s-triazole	GR	2,500 to 14,700	Moderate	Rats	4-1/4 cups	Low	Water-soluble liquid and powder
Amitrole-Simazine		GR;SS						
Amitrole-T	3-amino-s-triazole + ammonium thiocyanate	GR	5,000			1-1/2 cups		Water-miscible liquid
AMS	Ammonium sulfamate	C	3,900	Moderate	Rats	1 cup	None	Water-miscible liquid Water-soluble powder
Aromatic solvents		C;Aq		High			Moderate	
Atrazine	2-chloro-4-(ethylamino)-6-(isopropylamino)-s-triazine	P	3,080	Moderate	Rats	1 cup	None	Wettable powder
BDM	Borate-2, 4-D	SS		Moderate			Low	
Benefin	N-butyl-N-ethyl-trifluoro-2,6-dinitro-p-toluidine	P	10,000	Low	Rats	3 cups	Low	Emulsifiable concentrate
Bensulide	O,O,diisopropyl phosphorodithioate S-ester with N-(2-mercaptoethyl) benzenesulfonamide	P	770	Moderate	Rats	3/5 cup	> 3,950 (rabbit)	Emulsifiable concentrate Granular base
BMM	Borate-Monuron	SS		Moderate			Low	
Borate-Chlorate-Bromacil		SS						
Bromacil	5-bromo-3-sec-butyl-6-methyluracil	SS	5,200	Low	Rats	1-1/2 cups	Moderate	Wettable powder

TABLE 1 (Continued)
Chemical, Physical, and Biological Properties of Herbicides for Noncropland Use

Designation	Chemical	Principal use or action[1]	Acute oral toxicity		Test animal	Acute oral toxicity for 150-lb. man[3]	Dermal toxicity	Commercial formulation
			(LD_{50}) Mg/Kg[2]	Rating				
Cacodylic acid	Hydroxydimethylarsine oxide	C	830 to 1,350	Moderate	Rats	4 tblsp.	Low	Water-soluble solid
Calcium cyanamide		S	1,400	Moderate	Rabbits			Granular base; water-soluble solid
CBM	Chlorate-Borate	SS		Moderate			Low	
CBMM	Chlorate-Borate-Monuron	SS		Moderate			Low	
CDEC	2-chloroallyl diethyldithiocarbamate	P	850	Moderate	Rats	4 tblsp.	Moderate	Emulsifiable concentrate Granular base
Chlorate-Chloride	Sodium chlorate & calcium chloride	SS		Low			Low	
Chlorpropham	Isopropyl m-chlorocarbanilate	P	5,000 to 7,500	Low	Rats	1-1/2 cups		Emulsifiable concentrate Granular base
Copper sulfate		Aq	15,000	Low			Very high	Water-soluble salt
Dalapon	2,2-dichloropropionic acid	GR;S	3,860 to 9,330	Low	Rats	1 to 2 cups	Low	Water-soluble salt
Dalapon-Silvex		GR;S		Moderate			Low	
DCPA	Dimethyl tetrachloroterephthalate	P	3,160	Moderate	Rats		None	Wettable powder
Dicamba	3,6-dichloro-o-anisic acid	GR	1,040 to 2,900	Moderate	Rats	1/2 cup		Water-soluble salt
Dichlobenil	2,6-dichlorobenzonitrile	S;P	3,160	Moderate	Rats	4/5 cup	>500	Granular base; wettable powder
Dinoseb	2-sec-butyl-4,6-dinitrophenol	C;P	5 to 60	Very high	Rats	2/5 teasp.	Very high	Emulsifiable concentrate
Diphenamid	N,N-dimethyl-2,2-diphenylacetamide	S;P	1,000 to 1,798	Moderate	Rats	5 tblsp.	>6,320	Wettable powder

TABLE 1 (Continued)
Chemical, Physical, and Biological Properties of Herbicides for Noncropland Use

Designation	Chemical	Principal use or action[1]	Acute oral toxicity		Test animal	Acute oral toxicity for 150-lb. man[3]	Dermal toxicity	Commercial formulation
			(LD_{50}) Mg/Kg[2]	Rating				
Diquat	6,7-dihydrodipyrido(1,2-a: 2',1'-c)pyrazinediium salts	C;Aq	400 to 500	High	Rats	2 tblsp.	>500 (rabbit)	Water-soluble Water-soluble salt
Diuron	3-(3,4-dichlorophenyl)-1, 1-dimethylurea	SS;P	3,400 to 7,500	Moderate to low	Rats	1 cup	Low	Granular base Water-miscible liquid Wettable powder
DSMA	Disodium methanearsonate	C	1,800 to 2,800	Moderate	Rats	4-3/5 tblsp.	None	Granular base Wettable powder Water-soluble
Endothall	7-oxabicyclo (2,2,1) heptane-2,3-dicharboxylic acid	C;Aq	38 to 206	Very high	Rats	2-1/2 teasp.	Moderate	Emulsifiable concentrate Granular base Water-soluble Water-soluble salt
EPTC	S-ethyl dipropylthio-carbamate	P	1,630 to 3,160	Moderate	Rats	1/2 cup	2,641 (rabbit)	Emulsifiable concentrate Granular base
Erbon	2-(2,4,6-trichlorophenoxy) ethyl 2,2-dichloropro-ponate	SS	1,120	Moderate	Rats	Moderate	Moderate	Emulsifiable concentrate
Fenac	(2,3,6-trichlorophenyl) acetic acid	S	1,780 to 3,000	Moderate	Rats	1 cup	3,160	Granular base Water-soluble Water-soluble salt Water-soluble powder
Fenuron	1,1-dimethyl-3-phenylurea	SS	6,400	Low	Rats	1-4/5 cups	Low	Granular base Wettable powder
Herbicidal oils		C						

TABLE 1 (Continued)
Chemical, Physical, and Biological Properties of Herbicides for Noncropland Use

Designation	Chemical	Principal use or action[1]	Acute oral toxicity		Test animal	Acute oral toxicity for 150-lb. man[3]	Dermal toxicity	Commercial formulation
			(LD_{50}) Mg/Kg[2]	Rating				
Metham	Sodium methyldithio-carbamate	SF	3,000 to 5,000	Moderate	Rats		Moderate	Water-miscible liquid
Methyl bromide	Methyl bromide	SF	35	Very high		2 drops	Very high	Compressed gas
	Methyl bromide and Chloropicrin	SF						
	Methyl isothiocyanate + Chlorinated, C_3hydro-carbons	SF						
MH	1,2-dihydro-3,6-pyridazinedione	GR	6,950	Low	Rats	1 cup	4,000	Wettable powder Water-soluble salt
Monuron	3-(p-chlorophenyl)-1,1-dimethylurea	SS	3,600	Moderate	Rats	1 cup	Low	Granular base Water-miscible liquid Wettable powder
MonuronTCA	3-(p-chlorophenyl)-1,1-dimethylurea trichloroacetate	SS	1,800 to 3,700	Moderate	Rats		>1,000	
MSMA	Monosodium methanearsonate	C	700 to 1,800	Moderate	Rats	1/2 cup		Emulsifiable concentrate Water-soluble salt
Naptalam	N-1-naphthylphthalamic acid	P	8,200	Low	Rats	2-2/5 cups	Low	Emulsifiable concentrate Granular base Wettable powder
Norea	3-(hexahydro-4,7-methanoindan-5-yl)-1,1-dimethylurea	P	1,476	Moderate	Rats	1/2 cup	23,000	Wettable powder
Paraquat	1,1'-dimethyl-4,4'-bipyridinium salts	C	157	High	Rats	2 teasp.	Moderate	Water-miscible liquid Water-soluble

TABLE 1 (Continued)
Chemical, Physical, and Biological Properties of Herbicides for Noncropland Use

Designation	Chemical	Principal use or action[1]	Acute oral toxicity		Test animal	Acute oral toxicity for 150-lb. man[3]	Dermal toxicity	Commercial formulation
			(LD_{50}) Mg/Kg[2]	Rating				
PCP	Pentachlorophenol	C	27 to 210	Very high to high	Rats	1 teasp.	Very high	Emulsifiable concentrate Flakes, pellets, wettable powder
Picloram	4-amino-3,5,6-trichloropicolinic acid	GR;SS	8,200	Low	Rats	2-2/5 cups	>4,000 (rabbit)	Granular base Water-soluble concentrate
Prometone	2,4-bis(isopropylamino)-6-methoxy-s-triazine	S	2,980	Moderate	Rats	4/5 cup	Low	Emulsifiable concentrate
Prometryne	2,4-bis(isopropylamino)-6-(methylthio)-s-triazine	S;P	3,750	Moderate	Rats	1 cup	Low	Wettable powder
Sesone	2-(2,4-dichlorophenoxy) ethyl sodium sulfate	P	1,000 to 1,230	Moderate	Rats	6-1/2 tblsp.		Granular base Water-soluble Water-soluble salt
Siduron	1-(2-methylcyclohexyl)-3-phenylurea	P	5,000 to 7,500	Moderate	Rats	1-1/2 cups	>5,500	Wettable powder
Silvex	2-(2,4,5-trichlorophenoxy) propionic acid	GR	375 to 1,200	High to Moderate	-do-	2-2/5 tblsp.	Low	Emulsifiable concentrate Granular base Water-soluble salt
Simazine	2-chloro-4,6-bis (ethylamio)-s-triazine	P;S	5,000	Moderate	-do-	1-1/2 cups	None	Wettable powder
Sodium chlorate	Sodium chlorate	SS;C	1,350 to 5,000	-do-	-do-	1-1/2 cups	Low	Water-soluble powder Water-soluble solid
Stoddard solvent		C	2,000	Moderate	-do-			Oil
TCA	Trichloroacetic acid	S;GR	5,000	Moderate	-do-	1-1/2 cups	High	Water-soluble Water-soluble salt

TABLE 1 (Continued)
Chemical, Physical, and Biological Properties of Herbicides for Noncropland Use

Designation	Chemical	Principal use or action[1]	Acute oral toxicity		Test animal	Acute oral toxicity for 150-lb. man[3]	Dermal toxicity	Commercial formulation
			(LD_{50}) Mg/Kg[2]	Rating				
Terbacil	3-tert-butyl-5-chloro-6-methyluracil	S				1-1/2 cups		
Terbutol	2,6-di-tert-butyl-p-tolyl methylcarbamate	P	34,600	Low				
Trifluralin	α,α,α-trifluro-2,6-dinitro-N,N-dipropyl-p-toluidine	P	3,700 to 10,000	Low	Rats	3 cups	>5,000	Emulsifiable concentrate Granular base
2,3,6-TBA	2,3,6-trichlorobenzoic acid	S;GR	750 to 1,644	Moderate	-do-	1/2 cup	>1,000	Emulsifiable concentrate Granular base Soluble in organic solvents Water-miscible liquid Water-soluble salt
2,4-D	(2,4-dichlorophenoxy) acetic acid	GR	300 to 1,000	High to moderate	Rats	2-2/5 tblsp.	Low	Emulsifiable concentrate Water-miscible liquid Water-soluble salt Water-soluble powder
2,4,5-T	(2,4,5-trichlorophenoxy) acetic acid	GR	300 to 500	High	Rats	4 teasp.	Low	Emulsifiable concentrate Water-miscible liquid Water-soluble salt

[1]Aq, aquatic; C, contact; GR, growth regulator; P, preemergence; S, soil; SF, soil fumigant; SS, soil sterilant.
[2]Milligrams of herbicide per kilogram of body weight of animal specified.
[3]Teasp. – teaspoons; tblsp. – tablespoons.

Liquid concentrates and powders should be put into containers that can readily be lifted by the operator in the field. Packages of powders should be small enough so that it is unnecessary to remove the contents with a scoop.

(3) Inhaling vapors, dusts, and spray mists can also be avoided. Use a mask approved for the particular type of exposure, when lable directions indicate the need. In the case of a severe exposure, move the patient into fresh air, administer artificial respiration if needed, and call a physician.

(4) Some chemicals are flammable or support fire. Avoid ignition from friction, sparks, and contact with combustible materials.

(5) Some are dyes that color skin and hair if not protected.

1.3.2 Livestock. For most herbicides, the chief dangers of poisoning livestock come from the consumption of herbicide remnants in open containers, or spilled on the ground or floor. Very toxic herbicides, such as sodium arsenite, kill livestock that eat treated forage.

Herbicides are often used to eradicate or control undesirable plants that may be poor for forage. Therefore, livestock environment is nearly always improved through chemical control, by the replacement of undesirable plants with desirable forage plants. 2,4-D and similar compounds may increase the palatability of plants not ordinarily eaten. If these are poisonous species such as Jimson weed, larkspur, and hemlock, sickness and death may result. The nitrate content of some plants may be increased when sprayed with 2,4-D. This nitrate is reduced to nitrite by microorganisms in the intestinal tract of herbivorous animals. Because nitrite in the blood stream interferes with the effective transport and use of oxygen, the animal suffocates. However, increased nitrate content of plants does not always follow spraying. Furthermore, some natural conditions also produce high nitrate, so that many weeds contain enough to cause poisoning whether sprayed or not. More commonly nonfertilized soils are so low in nitrogen content that nitrite poisoning is no hazard.

1.3.3 Desirable Plants. Certain precautions are necessary to prevent damage to adjacent valuable plants. This damage may result from drift, washing, or leaching.

(1) Drift hazards are greatest when herbicides affecting the leaves of plants are used. These may be of the growth-regulating type—such as 2,4-D, 2,4,5-T, and silvex; or of the contact type—such as PCP, the petroleum oils, and dinitros. Danger is least when dry applications are made of nonvolatile herbicides. Drift occurs not only with volatile herbicides, such as the high-volatile esters of 2,4-D and 2,4,5-T; but also from a spray that has been atomized into a mist by high pressure and small nozzle opening whether the formulation is volatile or not. The control of drift is discussed on page 32 and 155.

(2) Washing is an important hazard on slopes, bare ground, and pavements. The herbicide may be carried by surface runoff to valuable plants downslope. Do not drain or flush equipment where runoff to desirable plants may occur.

(3) Leaching moves chemicals downward through the soil. If they are readily absorbed by roots, plants whose roots extend under the treated area are likely to be injured. Avoid treating such areas with soil sterilants. Do not drain or flush equipment where leaching to the roots of desirable plants may occur.

1.3.4 Equipment. Some chemicals corrode the metal parts of spraying equipment; oils and solvents injure rubber. Thorough draining and cleaning of equipment with water and a detergent is sufficient protection against most chemicals. When corrosive chemicals are used, coat the metal parts of the equipment with protective paint, oil or undercoating after use, or purchase equipment with noncorrosive metals. Teflon and neoprene rubber are resistant to oils and solvents.

1.3.5 Fish and Wildlife. Applications of herbicides may have primary and/or secondary effects on wildlife. Primary effects are toxicological and physiological. In general, primary effects of herbicides on wildlife have not been serious.

Secondary effects of herbicides on wildlife include toxicological effects due to sublethal doses, changes in palatability of poisonous plants, changes in the chemical composition of plants, and ecological effect in the habitat by injury, contamination, or death of organisms in the food chain. All herbicides have the potential of exerting major secondary effects on wildlife through ecological change, for herbicides are used to eliminate or reduce the numbers of certain plants to provide for the increase of other plants. These ecological changes in the habitat may well lead to increases or decreases in wildlife numbers.

There are a few herbicides, such as dinitros, that can poison animals. Most injury results from overdoses and spillage. Promiscuous spraying can distroy cover, but herbicides can also be useful in management. Openings in wooded areas, such as the clearing for utility company rights-of-way and spraying of hardwoods in stands of pines, can be beneficial to wildlife.

A few herbicides are very toxic to fish, but many can be used safely for the control of aquatic weeds. The control of submersed weeds in ponds or streams can be beneficial to fish populations. Safe amounts of herbicides, expressed in parts of the chemical per million parts of water, vary widely with age, size, and species of fish.

Whenever a proposed spraying program might endanger fish and wildlife, consult Federal or State Fish and Wildlife Service for advice.

1.3.6 Herbicide Labels. Labels on the herbicide container are written with great care to state only facts. Recommendations on labels for materials sold interstate must be registered with the U.S. Department of Agriculture before the label can be authorized. The label should always be read by the operator. It tells, first, what the herbicide is. For instance, 2,4-D is sold as a sodium or amine salt or a volatile or low-volatile ester. Recommendations differ for various herbicides and for various formulations of the same basic chemical.

The label tells the amount of acid equivalent, phenol equivalent, or active ingredient in the product. This information permits a comparison of concentrations in various formulations, a comparison that is useful for figuring amounts to apply and for contrasting prices. The label also makes recommendations for use, and gives rates and time of application. Certain warnings are stated, when necessary, to protect the operator and/or consumer from the hazardous effects or irritation by the chemical, and to protect susceptible plants from injury.

To Control Weeds With Chemicals

1. Identify the weeds you want to control. If in doubt, obtain assistance from a weed specialist or other authoritative source.

2. Select the right herbicide to control these weeds without harm to desirable plants nearby.

3. Follow chemical mixing directions. Do not use more than recommended amounts.

4. Remember that weather conditions, the soil, and the growth stage of the weeds affect the action of many herbicides. So, follow directions on when and how to apply the materials.

Section 2. CHARACTERISTICS OF HERBICIDES DISCUSSED

Common names or designations of noncropland herbicides used in Table 1 are those accepted or preferred by the Weed Science Society of America, the American National Standards Institute, and the Federal Committee on Pest Control. Chemical names are those used by Chemical Abstracts Service of the American Chemical Society. Trademarks or trade names used by the herbicide industry are not cited except when they are common names and do not indicate an endorsement of the product.

Acute oral toxicity of herbicides in milligrams of herbicide per kilogram of body weight of laboratory test animals, toxicity rating, and the estimated oral toxicity for a 150-pound man, are also presented in Table 1. Those herbicides rated very high must be handled with particular care, while those rated as low do not require special attention. Dermal toxicity is rated on the same scale, and the same relative caution should be required.

Available commercial formulations are also listed in Table 1. Emusified concentrates and wettable powders are readily dispersed in a water carrier and require agitation during the spraying operation. Water-soluble salts, water-miscible liquids, and water-soluble powders are completely miscible with water and normally do not require agitation. Granular materials are dispersed with special equipment.

An attempt has been made to classify the various herbicides as to principal use or action, such as contact, growth regulator, soil sterilant, soil, or preemergence. In some cases, an herbicide may fall into more than one class; such a classification cannot be too definite but is more of an indication. This information is also shown in Table 1.

Section 3. HERBICIDES FOR WEED CONTROL IN VARIOUS SITUATIONS

Weed control rates of application are often given in minimum and maximum amounts, depending on the situation. This spread is necessary to take care of differences in the response of species, the stage of growth when treatment is made, the period of residual toxicity desired, the amount and distribution of rainfall, soil texture and composition, and other environmental conditions. In general, the proper rate for a specific situation can be determined from suggestions in Table 2.

TABLE 2
Situations Where Light and Heavy Rates of Herbicides Are Needed

Light rates	Heavy rates
Herbaceous plants	
Susceptible species	Tolerant species
Annuals	Perennials
Seedlings	Annuals and biennials in flower
Perennials in bud	Established perennials —flower to maturity
Shallow-rooted	Deep-rooted
Woody plants	
Susceptible species	Tolerant species
Foliage applications when plants are in full leaf	Foliage applications before and after full leaf
Actively growing	Dormant
Residual toxicity	
Short period	Several years
Arid regions	Humid regions
Soil type	
Low in organic-matter content	High in organic-matter content
Low in clay content	High in clay content
Well drained	Poorly drained
Root-absorbed chemical	
Bare soil	Heavy trash

In some cases, rates are given in units of the chemical per 100 or 1,000 square feet, per square rod, or per acre. It is not necessary, however, to measure the area to be sprayed each time an application is made. Calibrate the sprayer for the volume of spray delivered per unit of area. If the amount of chemical per unit volume is known, the rate per unit area is easily determined. See Section 6, paragraph 6.3.1.

Spray volume depends on foliage density. For soil applications, it can be as low as the sprayer will distribute uniformly, except that it should be increased where trash or vegetation is present.

Information on noncropland weed control is presented in Table 3. Herbicides that kill all vegetation are listed in the first section of the table; while the second section contains those that work best on broadleaf weeds. The herbicides are listed alphabetically.

3.1 ALL VEGETATION. There is no one herbicide available that meets all requirements for complete control of vegetation. At practical rates of application, even the soil sterilants do not always kill all vegetation. There are two major reasons. First, there are certain weed species that are resistant to each of the soil sterilants listed in this handbook; and, second, these herbicides do not behave equally well under all evironmental conditions. To be effective, a soil sterilant must be soluble enough to be carried into the root zone by soil water; also, it must remain long enough for a lethal dose to be absorbed by the plant. Aside from the relative solubility of the chemical, its movement and persistence in the soil are influenced by (1) the rainfall pattern of the area; (2) the physical and chemical properties of the soil, such as texture, structure, and pH; and (3) the micro-organisms in the soil that are able to deactivate the chemical.

Failure to get expected control may result from an incomplete distribution of the herbicide in the soil or from amounts in the soil solution inadequate to effect a kill. A chemical of low solubility may be adsorbed in the upper soil layer and not reach deeper roots. This may happen in soils with poor underdrainage, in dry regions, or when the treatment was made at the wrong time. A soluble chemical may leach out of the soil before plant roots absorb a lethal dose. This occurs most commonly in sandy soils with excessive underdrainage and where rainfall is high, in seasons of heavy showers, and under irrigation. It may also result from improper timing of the treatment. When hard-to-kill species are a problem or where environmental factors reduce the activity of a chemical, (1) increase the rate of application, (2) use a mixture of chemicals, or (3) repeat the treatment.

The rates of application and the optimum time for treatment also vary with soil, rainfall, and the weed species to be controlled. In most areas, it is better to make repeated annual applications of soil sterilants at relatively light rates than to rely on a single heavy treatment. Such a maintenance dosage results in a smaller annual expenditure than a "one shot" method and keeps chemicals in the surface soil where they can kill weed seeds coming in from outside. Nongrass species are usually the

TABLE 3
Noncropland Weed Control

Herbicide	Rate[1] in pounds per acre	Time of application	Weeds controlled	Remarks
All vegetation				
Amitrole	3 to 5	Early growth to first bloom	Annual grasses and broadleaf weeds	Keep away from canals and reservoirs
Amitrole-T	4 to 8	Early growth to first bloom	Perennial grasses	Keep away from canals and reservoirs
Amitrole+dalapon +monuron +simazine +TCA	Follow instructions on labels	When plants are growing rapidly	Grasses and broadleaf weeds	Last longer than amitrole alone
AMS	50 to 300	Early growth to first bloom	Woody plants, mixed grasses, and broadleaf weeds	May be used adjacent to reservoirs and lakes
Atrazine	10 to 30	Preemergence or before plants are 1-1/2" tall	Non-selective	Lasts at least one year
Borate-sodium chlorate	450 to 650	In spring when weeds are small	Non-selective	
Bromacil	3 to 8	In spring when weeds are small	Both grass and broadleaf weeds	
BDM	440 to 3,400	When sufficient moisture to carry into root zone	Broadleaf weeds only	
BMM	220 to 1,700	Fall, winter or early spring	Both grass and broadleaf weeds	

TABLE 3 (Continued)
Noncropland Weed Control

Herbicide	Rate[1] in pounds per acre	Time of application	Weeds controlled	Remarks
All vegetation – continued				
Bromacil	3 to 25	Early growth	Both grass and broadleaf weeds	Lasts for more than one year; active through absorption by plant roots
CBM	440 to 2,000	Post emergence	Broadleaf weeds and grasses	Lasts more than 1 year Gives quick top kill
CBMM	440 to 1,000	Annuals in spring; perennials, fall or winter	Broadleaf weeds and grasses	Lasts more than 1 year
Sodium chlorate-calcium chloride	480 to 1,600	Avoid application before long rainy period	Non-selective	The calcium chloride reduces the fire hazard–caution still necessary
Dalapon	10 to 30	When plants are growing vigorously	Annual grass and some broadleaf weeds	Heavy rates for hard-to-kill weeds; more effective on grasses
Dalapon+silvex	8 to 12 Dalapon 1-1/2 Silvex	When plants are young and growing	Mixed grasses and broadleaf weeds	
Dicamba	5 to 10	Preemergence and foliar	Wide range of broadleaf weeds and some brush species	Use higher rates for perennial weeds
Diuron	10 to 40	Before period of adequate precipitation	General vegetation at higher rates	Lasts more than one season at higher rates

TABLE 3 (Continued)
Noncropland Weed Control

Herbicide	Rate[1] in pounds per acre	Time of application	Weeds controlled	Remarks
All vegetation – continued				
Erbon	120 to 160	Late spring in north; early to mid-winter in California	General vegetation	Lasts at least 1 season
Fuel oil fortified with dinoseb	80 to 160	On young growth	General weed control	Contact herbicide–repeat as necessary
Monuron	20 to 60	Before period of adequate precipitation	General vegetation	Lasts more than one season at higher rates
MonuronTCA	20 to 60	When weeds are young and succulent	Non-selective	Lasts 6 to 18 months
Oils, herbicidal	80 to 160 gal.	When plants are growing	General herbicide	Contact herbicide, repeat as necessary; fortify with 2,4-D, TCA, or dalapon for oil-tolerant species
Paraquat	0.5 to 2	On young growth	Non-selective	Contact herbicide; always use proper surfacant; repeat as necessary
Prometone	10 to 60	On early growth	-do-	Mix with oil or water; oil kills top growth quicker
Simazine	10 to 30	Preemergence	General weed control	Lasts at least one year
Sodium chlorate	480 to 1,600	Avoid application before long, rainy period	Non-selective	Lasts 1 to 4 years Fire hazard–observe all precautions

TABLE 3 (Continued)
Noncropland Weed Control

Herbicide	Rate[1] in pounds per acre	Time of application	Weeds controlled	Remarks
All vegetation – continued				
TCA	50 to 200	When rain can be expected	Non-selective	Effective on most grasses; lasts 1 year or longer
2,3,6-TBA	10 to 30	When weeds are in succulent growth	Mostly broadleaf weeds	May persist in soil 1 to 3 years
Broadleaf herbaceous weeds (selective control in desirable grasses)				
Dicamba	0.25 to 1	Early growth in spring	Annuals, shallow-rooted seedling perennials, and susceptible perennials	Often used in mixtures with 2,4-D; avoid spraying close to conifer trees and shrubs
Picloram	0.3 to 2	Vigorous spring growth	Annual and perennial broadleaf weeds	Avoid drift; persists for 3 years or more in some soils; avoid areas near irrigation canals
Picloram + 2,4-D	0.5 to 2	Vigorous spring growth	Annual and deep-rooted perennial weeds	Avoid drift; persists for 3 years or longer; avoid spraying areas near irrigation canals
2,4-D	1 to 4	Rapid vegetative growth	Annual and deep-rooted perennial weeds	Repeat as necessary
2,4,5-T	1 to 4	Rapid vegetative growth	Annual and deep-rooted perennial weeds	Use for susceptible weeds; difficult to control with 2,4-D
Weedy grasses where control of broadleaf weeds is not necessary				
Amitrole	8 to 12	On young growth	Phragmites and reed canary grass	Repeat 2 to 3 times each growing season; keep away from canals and reservoirs

TABLE 3 (Continued)
Noncropland Weed Control

Herbicide	Rate[1] in pounds per acre	Time of application	Weeds controlled	Remarks
Weedy grasses where control of broadleaf weeds is not necessary – continued				
Amitrole-T	4 to 6	On young growth	Phragmites and reed canary grass	Repeat 2 to 3 times each growing season; keep away from irrigation canals and reservoirs
Dalapon	10 to 30	On young growth	Annuals and established perennials	Repeat as necessary
DSMA or MSMA	2.5 to 5	When weeds are in active growth	Johnson grass, nutsedge, cocklebur, and many annual grasses; poor control of many broadleaf weeds; does not control bermuda grass	
Fuel oil fortified with dinoseb or PCP	80 to 160 gal.	On young growth	Established perennials	Repeat treatment required
TCA sodium	40 to 120	On aftermath in fall	Established perennials	Apply in late autumn; may seed desirable grasses next season

[1]Rates and concentrations usually are given in terms of acid equivalent or active ingredients rather than commercial formulation.

first vegetation to reinfest sterilized areas. Relatively inexpensive treatments with esters of 2,4-D at 1 pound per acre will maintain areas free of vegetation for several additional years. Spot treat difficult-to-treat plants by hand rather than with a general spray treatment at rates high enough to kill the tolerant weeds.

Where perennial weeds are susceptible to the phenoxy herbicides, it is economical to use a relatively insoluble soil sterilant like simazine or diuron to control annual weeds, and 2,4-D or silvex to kill the perennials. The soil sterilant is applied preemergence to moist soil at 4 pounds per acre in water. The phenoxy compound is applied to perennials at 1 pound per acre when they are in full leaf and growing rapidly, to induce the maximum translocation to their roots. For this method to be successful, the soil sterilant must remain near the surface and there must be enough rain to activate it. Heavy rain will leach the herbicide and shorten the period of control. Incorporation of the chemical with the soil helps activate it in dry seasons, but this does not substitute for rain.

3.1.1 Relatively Permanent Soil Sterilants. Soil sterilants prevent the growth of green plants. The soil may or may not be sterile. These chemicals are used in storage areas, lumberyards, and parking lots; on tennis courts and racetracks; under pipelines and transformer cages; under guardrails and around signposts on highways and lights on runways; near fire hydrants, trestles, and bridges; on public utility rights-of-way; on gravel blanket areas; around buildings, grain elevators, utility poles, and tank farms; along fence rows; for firebreaks; and in similar areas where any plant growth is undesirable. There are four major problems in maintaining bare ground: (1) no herbicide kills all species at reasonable rates of application; (2) reinfestation results from weed seeds in the soil after the herbicide has been leached below the surface; (3) desirable plants in adjoining areas may be killed or injured if surface water drains across treated areas to untreated ones, or if tree roots extend into treated areas; (4) bare soil is subject to serious erosion where the terrain is steeply sloped and there is sufficient rainfall to cause runoff. Meet these problems by choosing the appropriate herbicide for the situation; and use satisfactory soil binding, stabilizing treatments, or structures to prevent erosion.

3.2 WEEDS IN SPECIFIC AREAS.

3.2.1 Paved Highways. Vegetation that encroaches upon the edges of concrete or asphalt pavement, or grows up through cracks and holes, causes premature breakdown of the pavement. Control with presurface and postsurface applications of herbicides is possible. Shoulders immediately adjacent to the trafficway, medians separating divided highways, and islands at highway intersections are often surfaced with asphalt. On such areas, apply herbicide to the gravel base just before it is "shot" with asphalt. A standard highway watering truck can be adapted for this use by equipping it with a loading pump, to circulate the spray material, and standard asphalt nozzles that deliver a fan spray.

Several herbicides prevent the emergence of plants through the pavement, but they vary in cost and in injury to vegetation adjacent to the paving. Plant growth on

the unpaved area, particularly on fill slopes, may be desirable to prevent erosion. Some herbicides for controlling this vegetation are listed in Table 4.

Postpaving treatments will be necessary later to prevent encroachment from unpaved areas and to control vegetation growing up through the cracks in old pavements. Soil sterilants, including bromacil, diuron, monuron, and TCA, may be used to prevent reinfestation of treated areas.

Care should be exercised to prevent damage to desirable vegetation when using bromacil, monuron, and borate-chlorate. Bromacil, diuron, and monuron will injure trees adjacent to treated areas.

3.2.2 Railroads. Three distinct railway areas require weed control: the ballast, the roadbed, and the right-of-way. The ballast is a 12- to 16-foot-wide strip, made up of coarse material such as cinders and gravel, that should be kept free of weeds. Because it is porous, it does not retain chemicals well. Insoluble herbicides—those absorbed through the leaves—and contact herbicides are most suitable. The roadbed (berm) beyond the ballast requires weed control, but elimination of vegetation increases erosion. The rest of the area to the right-of-way fence is similar to roadsides. If control is effected during the first 2 years by heavy rates of application, it can be maintained then with reduced rates. The effectiveness of some soil sterilants like bromacil, diuron, and simazine may not show up until the second or third year of use, especially in dry areas or with deep-rooted weeds.

Specific treatments adapted to different regions of the United States (Figure 1) are presented in Table 4.

3.2.3 Reinfested Areas. To kill weeds and seedlings of biennials and perennials that reinfest an area, use 2 pounds 2,4-D and 20 to 30 pounds dalapon and 1 cup wetting agent in 50 gallons of water per acre. For species resistant to 2,4-D, use amitrole at 4 pounds active ingredients in 100 gallons of water per acre. Repeat applications as necessary. See Table 3 for soil sterilants that prevent reinfestation.

3.3 WOODY PLANTS. Noncropland control of woody plants—trees and shrubs—is quite important. On military reservations, trees and shrubs must be removed for a clear line-of-sight on small-arms and artillery ranges, and from around ammunition magazines. Woody plants must also be kept under control along highways, under powerlines, along fence rows, and at the ends of airport runways.

Some of this growth can be cut mechanically; where this is not possible or practical, chemicals may be applied from the air or the ground using either sprays or pellets. Both selective and non-selective herbicides for killing woody plants are available and are applied in various ways, depending on the plants to be treated and their geographical location.

3.3.1 Foliage and Soil Applications. Both foliage and soil applications of herbicides may be used for the general control of woody plants. These are listed in Table 5 along

TABLE 4

Herbicides and Herbicide Mixtures To Be Used Under and Along Paved Highways, Railroad Ballast, and Roadbeds in Various U.S. Regions

Number	Pounds per acre[1]									Total pounds bora-chlorate	Total gallons oil-PCP	Region[2] of application	Vegetation controlled
	Acid equivalent				Active ingredients								
	Dalapon	Silvex	TCA	2,4-D	Amitrole	Bromacil	Diuron	Monuron	Simazine				
1			30					50				2,3	Most kinds
2								50				5,6	Most kinds
3				4				8			20	3,5,6	Most kinds[3]
4								80				2,3,4,6,7	Most kinds
5				4				15			20	5,6,7	Most kinds[3]
6	20			4					4			1,2,3,4	All kinds
7	20			4				8				1,2,3,4,7	All kinds[3]
8	16			4				20				1,2,3,4	All kinds
9										1,600		1,2,3,5,6	All kinds
10							80					1,2,3,4	Most kinds[4]
11								40		1,000		1,5,6,7	All kinds[4]
12	10			2								All	Annuals only[3]
13						8						All	Most kinds
14	20				5							All	Mostly grasses
15	40	4										All	Most kinds
16											100	3,4,6,7	All kinds[5]
17	40			6								All	Most kinds
18			100									All	Grasses only
19	82	10										All	Most kinds
20	90											All	Perennial grasses

[1] To convert to rates per foot-mile along pavements, divide by 8.25.
[2] For regions, see Figure 1.
[3] Best suited for annuals and shallow rooted perennials. Usually must be applied two or more times each year.
[4] Will prevent all revegetation for one to several years.
[5] Gives only temporary control. Repeat as necessary to maintain desired degree of control. Minimum drift injury to cotton, grapes and other crops sensitive to 2,4-D.

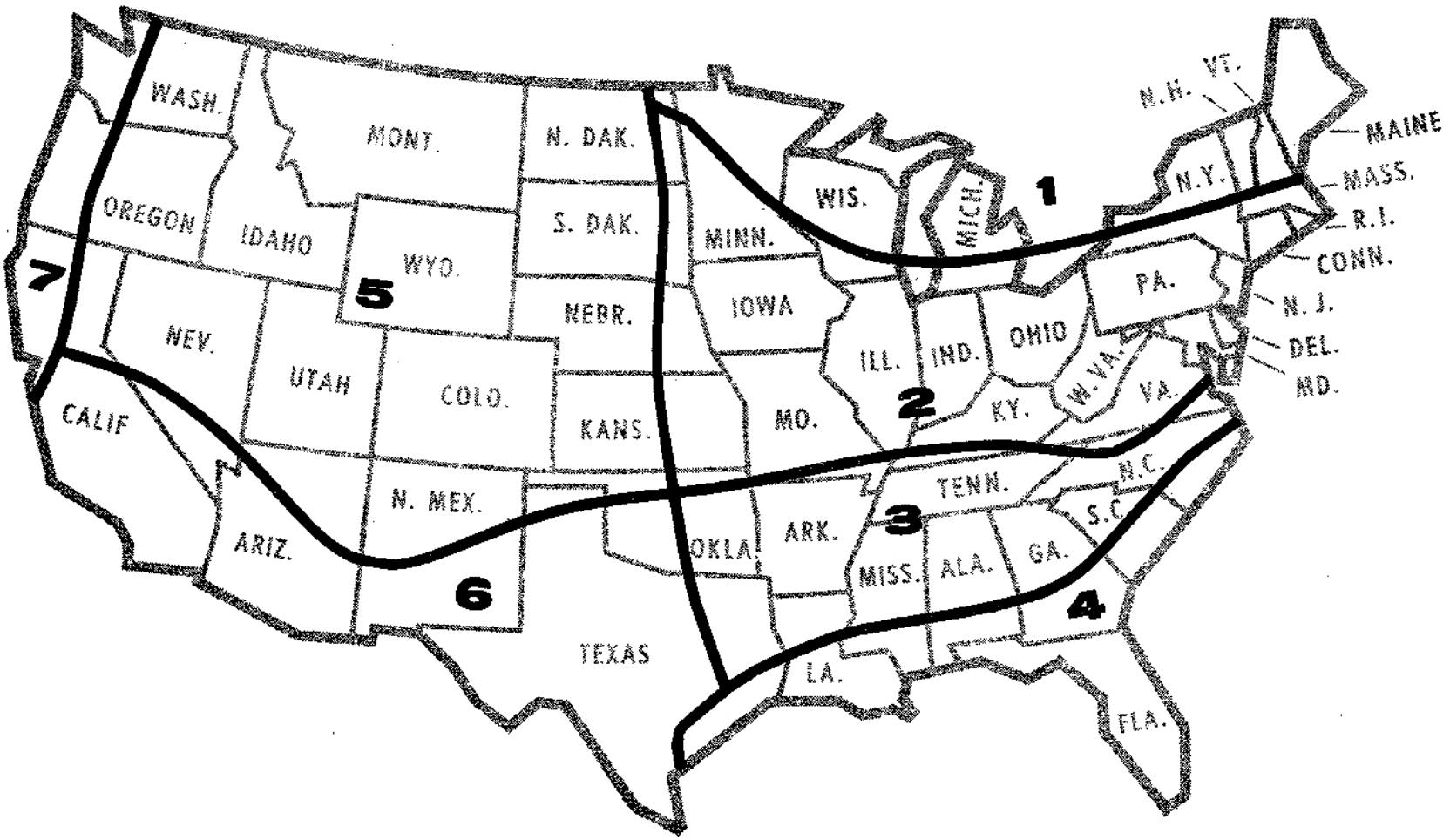


FIGURE 1

Regions of Somewhat Similar Soil Types, Climate, Vegetation, and growing season

TABLE 5
Herbicides To Control Woody Plants

Herbicide	Rate[1] in pounds per acre	Time of application	Weeds controlled	Remarks
Foliage applications				
Amitrole	3 to 6	Early growth, first bloom	Poison ivy, ash, and white locust	Drift of spray less hazardous to susceptible species than drift with 2,4-D and 2,4,5-T
AMS	60 to 80	When brush or trees are in full leaf	Woody plants	Corrosive to equipment
Dicamba + 2,4-D or 2,4,5-T	1.25 Dicamba + 2.5 2,4-D or 2,4,5-T	When in full leaf	Wide variety of trees and shrubs	See label for rates to use
Picloram + 2,4-D	2 to 4	Trees in full leaf	Many broadleaf and conifer species	Registered for use only on non-cropland; avoid spraying near canals and streams
Silvex	2 to 4	Spring and early summer	Effective on maples, some oaks, and others	
2,3,6-TBA	10 to 20	During active growth	Persimmon, woody vines	
2,4-D	2 to 4	Spring or early summer	Species susceptible to 2,4-D	Avoid drift to susceptible crops
2,4-D + 2,4,5-T (2:1 or 1:1 mixture)	3 to 4	-do-	Mixed species	-do-
2,4,5-T	2 to 4	-do-	Many species of woody plants	-do-

TABLE 5 (Continued)
Herbicides To Control Woody Plants

Herbicide	Rate[1] in pounds per acre	Time of application	Weeds controlled	Remarks
Soil application				
Fenuron	12 to 18	During adequate precipitation	Brush and some trees	Most effective on oaks; comes in both liquid and granular form
Fenuron TCA	12 to 25	-do-	-do-	-do-
Monuron	10 to 20	When ground is frozen	Most effective on oak	High rate will give control for 2 years
Picloram	6 to 8.5	During adequate precipitation	Wide variety of trees	May last in soil for 3 years; may be used as a foliage spray; avoid irrigation canals
Picloram-Borate	300 to 400	Spring and early summer	Number of trees, shrubs and vines	Keep away from desirable vegetation; avoid irrigation canals
Picloram + 2,4-D	5 to 25	In periods of rapid growth	More difficult to control brush species	Avoid spray drift; avoid irrigation canals

[1]Rates and concentrations are in terms of acid equivalent or active ingredient.

with brief directions for use. Table 6 contains more specific recommendations for the use of 2,4-D, 2,4,5-T or a mixture of the two for special woody plant problems in seven regions of the United States.

3.3.2 Larger Trees and Brush. When trees and brush have become rather large, special control measures are necessary. These include basal-bark and stump applications, and tree injections. In other cases, cut-surface applications such as frills and girdles, and cups and notches are best. Herbicides available for use with these methods are listed in Table 7.

3.3.3 Applications Along Roadsides and Utility Lines. Herbicides, if properly applied, are useful in the maintenance of roadsides and utility lines. The greatest dangers come from drift, runoff, improper application, and leaching to roots of desirable species under the treated area.

Before spraying, make a survey of the area, spotting slopes subject to erosion, location of desirable vegetation, and density and height of brush.

CAUTION: Drift hazards are greatest when growth-regulating herbicides—such as 2,4-D, 2,4,5-T, and silvex—or contact herbicides are used as sprays; but damage often results from careless application. Drift occurs not only with volatile herbicides, such as the esters of 2,4-D and 2,4,5-T, but also with any spray that has been atomized into a mist by high pressure and small nozzle opening. The volume of spray per unit area also influences drift. Where there are adjacent susceptible plants, use at least 10 gallons per acre and move sprayer at slow speed. It is especially important to reduce mist when spraying with a handgun. Operate at low pressure (30 to 60 p.s.i.). Direct spray downward as much as possible, and do not spray during windy conditions. When treating edges of roads, spray from the outside toward the pavement. Runoff is an important hazard on slopes, bare ground, and pavements. Cutback asphalt, applied with a soil sterilant, helps hold the chemical in place. Use 39 gallons per 1,000 square feet, or 1,700 gallons per acre, or use a light covering of road oil. If there has been an excavation, add a layer of crushed rock. Trees and shrubs some distance from oil treated with soil sterilants may be killed if their roots extend below this area.

Stump, basal-bark, and foliage applications are excellent for controlling brush and trees along roadsides and utility lines.

Stump applications are most satisfactory for killing trees along roadsides and controlling brush over 3 feet tall. Considerable labor is required, but the danger from falling branches is removed and there are no standing dead trees. Use esters of 2,4,5-T or 2,4-D plus 2,4,5-T at any time of the year, or AMS during the growing season. For rates of application, see Table 7.

Basal applications are practical for uncut brush and for regrowth from cut brush or trees. Make applications during the dormant season to avoid danger of injury from drift. Use esters of 2,4,5-T or 2,4-D plus 2,4,5-T. Rates of application are listed in Table 7.

TABLE 6

Specific Recommendations To Control Woody Plants in Seven Regions of the United States

Region[1]	Brush controlled	Chemical	Rate[2]	Remarks
1 & 2	Most brush	2,4,5-T	2 lb. per acre or 2 lb./100 gal. water (as a drenching spray)	
	Buckbrush and hazel	2,4-D	2 lb. per acre	In late May to mid-June
	Hard-to-kill species	2,4-D + 2,4,5-T	3 to 6 lb. in 10 to 25 gal. oil	Use as stem and foliage spray
	Elderberry, elm, eastern red cedar, sassafras, sumac, sweetgum, sycamore, walnut, wild plum, honeysuckle (top kill)	2,4-D + 2,4,5-T	8 lb. per acre	
3	Blackberries, brambles, common persimmon, prairie rose	2,4,5-T	3 to 4 lb. in 25 gal. oil + 75 gal. water	Drench foliage; use in late summer; avoid drift to cotton
	Buckbrush, skunkbrush	2,4-D	2 lb. per acre	-do-
4	Alder, bluejack, post and Turkey oak, persimmon	2,4,5-T	2 lb. per 100 gal. water	Drench foliage of Turkey oak in May or June; persimmon and post oak, in July and August
	Most deciduous upland hardwoods	2,4,5-T	2 lb. in 5 to 6 gal. oil-water emulsion per acre	Aerial spray
	Resistant species	2,4,5-T	4 lb. in 8 to 10 gal. per acre	Aerial spray
5	Willows and cottonwood	2,4-D + 2,4,5-T	3 to 4 lb. per 100 gal. of water	Drench foliage
	Chokecherries and wild rose	2,4,5-T	3 to 4 lb. per 100 gal. of water	Drench foliage
	Sagebrush	2,4-D	2 lb. per acre	

TABLE 6 (Continued)
Specific Recommendations To Control Woody Plants in Seven Regions of the United States

Region[1]	Brush controlled	Chemical	Rate[2]	Remarks
6	Mesquite (original growth)	2,4,5-T	1/3 lb. per acre in oil-water emulsion	Use 1/2 to 3/4 lb. per acre on regrowth
	Mesquite (dense stands)	2,4,5-T	3/4 lb. in 2 gal. diesel fuel + 8 gal. water per acre	
	Shinnery oak	2,4,5-T	1/2 lb. in diesel fuel or oil-water emulsion	Apply annually for 3 years
	Post oak	2,4,5-T	2 lb. per acre in diesel fuel or oil-water emulsion	Apply 2 successive years
	Sand sagebrush	2,4-D	1 lb. per acre in diesel fuel or oil-water emulsion	
7	General spraying	2,4-D + 2,4,5-T	2 lb. in 1 gal. diesel fuel + water to make 40 gal. per acre	
	Coyote brush	-do-	-do- 10 gal. per acre	
	Willow	-do-	-do- 100 gal. per acre	
	Aerial spraying in California	-do-	2 to 4 lb. in 1 gal. diesel fuel + water to make 10 gal. per acre	
	Individual plants	-do-	4 lb. in 1 gal. diesel fuel + 98 gal. water	Drenching spray
	Deciduous trees	-do-	8 to 12 lb. in 98 gal. diesel oil	Thoroughly wet base of tree trunk
	Evergreens	-do-	4 lb. in 1 gal. diesel oil in 90 gal. water	Drenching spray

[1]See Figure 1 for regions.
[2]Rates given are for low-volatile ester formulations. If volatilization is likely, use an amine slat formulation in water and increase rate 50 per cent.

TABLE 7
Herbicides for Treating Larger Trees and Brush

Method of application	Chemical and rate	Plants controlled	Remarks
Basal-bark (trunks less than 6" in diameter)	Ester of 2,4,5-T 12 to 16 lb. in 96 to 100 gal. diesel fuel	Most hardwood species	Cover all exposed bark just above ground line; let spray run down to bud zone; treat at anytime of year
Stump	Ester of 2,4-D or 2,4,5-T 12 to 16 lb. in 96 gal. diesel fuel	Most woody plants	Cover thoroughly the new wood of cut stump and bark to the ground; treat at anytime of year
	4 to 6 lb. AMS per gal. water	Ash, boxelder, cottonwood, maple, plum, willow	Use 1 tablespoon per 2 inches of diameter; spray or paint larger stumps; use crystals for stumps under 2 inches
Frills or girdles	Ester of 2,4,5-T or 2,4,5-T + 2,4-D 16 lb. per 100 gal. diesel fuel; amine salt of these herbicides in water is satisfactory in warm weather	Most woody plants	Treat at any time of year
	AMS 4 lb. per gal. of water	Ash, quaking aspen, hickory, maple, pecan, common persimmon, blackjack oak, post oak, red oak, sweet gum	
Cups or notches	AMS 1/2 oz. of crystals per notch or cup		Treat at anytime of year; space cups about 6 inches apart around trunk
Injections	Ester of 2,4,5-T; 33 lb. in 100 gal. diesel fuel; amine salt of 2,4,5-T in water is preferred in warm weather	For most hard woods	Treat at anytime of year
	Ester of 2,4,5-T + 2,4-D; 44 lb. in 100 gal. diesel fuel; amine salts of these herbicides are preferred in warm weather	-do-	Treat at anytime of year

Applications made in frills or girdles are more effective than basal treatments on large or thick-barked trees, and they prevent sprouting more effectively than stump treatments. Use 2,4,5-T or 2,4-D plus 2,4,5-T. See Table 7 for rates of application. Apply AMS in the same manner as for stump treatments.

3.3.3.1 Roadsides. For brush, after an initial clearance:

(1) Oaks and maples. (a) Use basal spray on clumps for maximum kill and minimum regrowth. Follow with basal sprays on nonsuckering species, or stem-foliage sprays on suckering species. Or, (b) use large volumes of stem-foliage spray. Follow in 2 to 3 years with a basal spray.

(2) Suckering species. Use overall stem-foliage spray. On susceptible species, repeat the following year; on resistant species, use basal sprays as followup.

For dense brush after hand cutting or light foliage spray:

(1) Oaks and maples. Drench the base of stems and stumps. Thoroughly wet the base of saplings that are not cut. Follow in 2 to 3 years with a basal spray in summer.

(2) Suckering species. Use overall stem-foliage spray. On susceptible species, repeat the following year; on resistant species, use basal sprays as followup.

For foliage applications, use esters of 2,4,5-T and 2,4-D on most species. Silvex is better on some oaks and locust. Use amitrole for white ash, black locust, poison-oak, and poison-ivy. Use AMS in areas where drift from 2,4-D or 2,4,5-T is too hazardous. It can be used successfully in a mist blower in areas where ordinary application methods are difficult.

3.3.3.2 Utility lines. Make two complete sprayings of all transmission lines at 2-year intervals—the first to kill as much growth as possible, and the second to kill escapees and resistant species. Spray only those species that grow tall enough to interfere with the lines. If they are over 6 feet tall, cut and spray the stump.

Fenuron pellets at 12 1/2 pounds per acre, active ingredient, kill alder, blackberries, and sumac; elderberry, elm, hawthorn, maple, or willow are not killed but all species are defoliated.

TCA and dalapon are moderately effective on conifers.

Foliage sprays of 2,4,5-T at 2 1/2 pounds per 100 gallons water control many species of hardwood brush throughout the season. They are most effective when applied soon after leaves are fully expanded and when the plants are growing actively. Esters of 2,4-D plus 2,4,5-T in equal proportions kill alder, smooth and staghorn sumac, and willow.

3.4 POISON-IVY, POISON-OAK, AND POISON-SUMAC. There are four satisfactory herbicides for killing poison-ivy, poison-oak, and poison-sumac—amitrole, AMS, 2,4,-D + 2,4,5-T, and 2,4,5-T. Apply when leaves are fully expanded, and wet the foliage to the point of runoff. Drench the stems as high as possible when the plants are growing on a wall, and allow the excess spray to run down to the roots. Plants growing in the shade require more amitrole or 2,4-D + 2,4,5-T mixture than those in the sun.

3.4.1 Amitrole. Use 2 to 4 pounds, active ingredient, per 100 gallons water. Amitrole does not vaporize readily, but spray drift can damage nearby plants. If ivy is growing on a desirable tree, cut ivy stem at ground level in winter and treat the sprouts after leaves come out in the spring. If ivy is intertwined with desirable plants, paint the ivy leaves with a long-handled brush. Mix 2 tablespoons of the 50-percent product in 1 quart water for the paint. Cover at least one-half of the leaves. Amitrole can also be applied dry.

Where brush is to be killed along with the ivy, oak, or sumac, 2,4-D + 2,4,5-T is effective on more species than amitrole.

CAUTION: Amitrole kills most lawn grasses. It is slow in action; effects may not show up for 2 or 3 weeks.

3.4.2 AMS. Use 2 to 2-1/2 pounds, 95-percent product, in 3 gallons water and add a spreader-sticker. AMS does not evaporate, but spray drift can damage nearby plants.

CAUTION: AMS sterilizes the soil for several months. For precautions in handling, see Section 5.6.

3.4.3 2,4-D and 2,4,5-T Mixture and 2,4,5-T. Use 2 to 3 pounds, acid equivalent, per 100 gallons water. If any regrowth occurs, repeat the application. 2,4-D + 2,4,5-T in diesel fuel is also effective when applied in late winter or early spring. Use 12 pounds 2,4,5-T per 100 gallons oil for dormant spray. Treat poison-sumac in the dormant stage to avoid skin poisoning.

CAUTION: Prevent drift by applying on calm days. Minute quantities of spray may injure susceptible plants. Treat in winter if sensitive plants are to be grown nearby.

3.5 WEEDS IN ORNAMENTAL AND HORTICULTURAL PLANTINGS. Herbicides may be used to control weeds in a wide variety of ornamental and horticultural plantings. This includes shrubs and trees along highways, in ornamental nurseries and beds, wind-breaks, or other functional uses. Some chemicals may be used in bulbs, and in herbaceous annuals and perennials. Usually when these plants become established they will keep most weeds under control.

There are a number of herbicides that are useful as soil fumigants; and others, as selective sprays. These are listed in Table 8, together with certain suggestions for

TABLE 8
Herbicides for Weed Control in Ornamental Plantings

Herbicide	Rate[1] per acre	Time of application	Weeds controlled	Remarks
		Soil fumigants		
Calcium cyanamide	50 to 75 lb.[2]	Preplant	Weeds germinating in upper 4" of soil	Work into top soil; delay seeding 3-6 weeks
Metham	1 qt.[3]	Preplant	Most weeds	Work into soil; plant 14 to 30 days after treatment.
Methyl bromide	1 to 2 lb.[3]	Preplant	Most weeds	Use gastight cover; planting may be done 72 hours after cover is removed
Methyl bromide + chloropicrin	300 to 500 lb.	Preplant	Annual and perennial weeds and grasses	Use gastight cover 24 to 48 hours; seeding 48 to 72 hours after removal of cover; for transplanting, aereate for 7 to 10 days
Methyl isothiocyanate + chlorinated C_3 hydrocarbons	40 to 50 gal.	Preplant	General weed control	Use gastight cover; some weeds are controlled without cover
		Selective herbicides		
Bensulide	10 to 15 lb.	After plants are established	Germinating crabgrass and other annual weed grasses	For well established plants
Cacodylic acid	1 to 2 gal.	Post emergence	General control of established weeds	Use as directed spray; inactivated on contact with soil
CDEC	4 to 6 lb.	Post planting in spring	Germinating annual weed grasses and some broadleaf weeds	Use as directed spray in established ornamentals

TABLE 8 (Continued)
Herbicides for Weed Control in Ornamental Plantings

Herbicide	Rate[1] per acre	Time of application	Weeds controlled	Remarks
Selective herbicides – continued				
Chlorpropham	4 to 8 lb.	Preemergence	Germinating annual weed grasses and broadleaf weeds in conifers	Use as directed spray and avoid contact with base of plants
DCPA	9 to 12 lb.	Preemergence in early spring	Many germinating annual weed grasses and some broadleaf weeds	Do not disturb soil after application
Dichlobenil	4 to 6 lb.	Spring, late fall and early winter	Wide range of germinating grasses and broadleaf weeds	Use in established woody ornamentals
Dinoseb	2 lb. + 50 gal. aromatic oil	Post plant in early spring	Established and germinating annual weed grasses and annual broad-leaf weeds	Use as a directed spray
Diphenamid	4 to 6 lb.	Preemergence	Many germinating annual weed grasses and some broadleaf weeds	Use in established plantings, either over top or directed spray
EPTC	3 to 6 lb.	Pre- or post plant	-do-	Must be soil incorporated
Naptalam	4 to 8 lb.	Before or after transplanting	-do-	Use in woody plants only; direct spray so as to strike nursery stock 3" or less above ground

TABLE 8 (Continued)
Herbicides for Weed Control in Ornamental Plantings

Herbicide	Rate[2] per acre	Time of application	Weeds controlled	Remarks
Selective herbicides – continued				
Norea	1 to 5 lb.	Preemergence	General; germinating weeds	May use in woody and herbaceous ornamentals; lasts 2 to 4 weeks
Paraquat	1 to 2 qt.	When weeds are young and succulent	Annual weeds and tops of perennial weeds	Use as directed spray; avoid drift
PCP	4 lb. + 50 gal. aromatic oil	Post plant in early spring	Established and germinating annual grass and broadleaf weeds	Use as directed spray
Prometryne	2 to 3 lb.	Preemergence	General, germinating weeds	May be used as directed spray, post emergence
Sesone	3 to 6 lb.	-do-	Germinating annual weed grasses and broadleaf weeds in conifers	Use as directed spray and avoid contact with base of plants
Simazine	2-1/2 to 5	In fall or spring before weeds emerge	Germinating annual weed grasses and broadleaf weeds, also quackgrass	For use in establishing woody ornamentals
Stoddard solvent	50 to 100 gal.	Post plant when weeds are up	General for established weeds	Use as directed spray on weed seedlings between rows
Terbacil	2 to 4 lb.	In spring before weeds emerge	Germinating annual grass and broadleaf weeds	Keep off foliage; do not use on lawns, walks, or driveways
Trifluralin	0.5 to 1 lb.	As preplant in ornamentals; when needed in established ornamentals	Germinating annual grass and some broadleaf weeds	Must be soil incorporated; long range control

[1]Rates and *concentrations* are in terms of acid equivalent or active ingredients, not necessarily of commercial formulation.
[2]Rate for 1,000 square feet.
[3]Rate for 100 square feet.

their use. In Tables 9, 10, 11, 12, and 13, ornamental plants—such as bulbs, herbaceous annuals, herbaceous perennials, shrubs and bushes, and trees—are listed together with their reactions to some herbicides that may be used for weed control in the plantings.

3.6 LAWN AND TURF WEEDS. Weeds in lawns, athletic fields, golf courses, parade grounds, the turf portions of roadsides, and railroad rights-of-way are controlled by good maintenance practices supplemented with chemical herbicides. It is important to prevent the encroachment of weeds by maintaining competition from vigorously growing turf grasses. The principal factors in maintenance are soil, grass, water, mowing, and pests. Herbicides that may be used for weed control in lawns and turf are listed in Table 14. In this table the chemicals are grouped as to action—those for all weeds, for mostly grass weeds, and for broadleaf weeds.

3.7 AQUATIC WEEDS. Acquatic weeds vary greatly in their nature and habit of growth, and in the type of aquatic environment in which they grow. This environment primarily determines which herbicide is the most effective and safe for controlling a given aquatic weed. Environmental examples are: (1) banks above the waterline of canals and ponds; (2) shallow edges of canals, lakes, and ponds in which emersed plants grow rooted in bottom mud, extending their leaves and stems well above the water's surface; and (3) flowing water in canals and drainage ditches as compared to nonflowing water in lakes and ponds.

Another determinant for selecting the most effective herbicide is the nature of the plant—whether it is a grass or grass-like plant (e.g., cattail, sedge), a broadleaf (dicot) emersed or floating plant with all or most of the foliage above the water, or a submersed plant growing entirely under water or with foliage extending to the water surface. The submersed weeds vary from those rooted in bottom mud to the leafless, rootless algae. Microscopic algae give water a greenish color that varies in intensity from a barely discernible tinge to a pea-soup color and density; objectionable odors

TABLE 9
Reaction of Some Bulb Crops to Certain Herbicides

Name	Reaction[1] to					
	Bensulide	CDEC	Chlorpropham	DCPA	Norea	Sesone
Daffodil (*Narcissus* spp.)	R			R		R
Dahlia (*Dahlia* spp.)	R			R		R
Daylily (*Hemerocallis* spp.)					R	R
Fressia (*Freesia* spp.)	R					
Gladiolus (*Gladiolus* spp.)	R	R	R	R		R
Iris (*Iris* spp.)		R		R		R
Narcissus (*Narcissus* spp.)	R					
Ranunculus (*Ranunculus* spp.)	R					
Tulip (*Tulipa* spp.)	R					

[1]R = Resistant

TABLE 10
Reaction of Some Annual Herbaceous Ornamental Plants to Certain Herbicides

Name	Reaction[1] to		
	Bensulide	DCPA	EPTC
Ageratum (*Ageratum* spp.)		R	
Alyssum (*Alyssum* spp.)	R	R	
Aster (*Aster* spp.)	R	R	
Babysbreath (*Gypsophila paniculata*)		R	
Bachelor's button (*Centaurea cyanus*)		R	
Bellflower (*Companula* spp.)		R	
Bloodleaf (*Iresine* spp.)		R	
Bugloss (*Anchusa* spp.)		R	
Candytuft (*Iberis* spp.)	R	R	
Carnation (*Dianthus cryophyllus*)		S	
Cinquefoil (*Potentilla* spp.)		R	
Coleus (*Coleus* spp.)		R	
Daisy (*Bellis* spp.)	R		
Geranium (*Geranium* spp.)		R	
Germander (*Teucrium* spp.)		S	
Geum (*Avens* spp.)		S	
Larkspur, candle (*Delphinium* spp.)		R	
Marigold (*Tagetes* spp.)	R	R	R
Mesembryantheum (*Mesembryantheum* spp.)		S	
Pansy (*Viola* spp.)		S	R
Petunia (*Petunia* spp.)		R	R
Pink button (*Dianthus latifolius*)		S	
Pokerplant (*Kniphofia* spp.)		R	
Primrose (*Primula* spp.)	R		
Purple Coneflower (*Rudbeckia* spp.)		R	
Rose, moss (*Portulaca* spp.)		R	
Salvia (*Audibertia* spp.)		R	
Scarletsage (*Salvia splendens*)		R	
Snapdragon (*Antirrhinum* spp.)		R	
Stock (*Mathiola* spp.)	R		
Stonecrop (*Sedum* spp.)		R	
Strawflower (*Helichrysum bracteatum*)		R	
Sundrops (*Oenothera* spp.)		R	
Sunflower (*Helianthus* spp.)		R	
Sweetpea (*Lathyrus odoratus*)	R	R	
Telanthera (*Alternanthera* spp.)		S	
Verbena (*Verbena* spp.)		R	
Violet (*Viola* spp.)		R	
Virginia spiderwort (*Tradescantia virginiana*)		R	
Wallflower (*Cheiranthus* spp.)	R		
Wormwood (*Artemesia* spp.)		R	
Zinnia (*Zinnia* spp.)	R	R	R

[1]R = Resistant
S = Susceptible

TABLE 11
Reaction of Some Perennial Herbaceous Ornamental Plants to Certain Herbicides

Name	Reaction[1] to				
	Bensulide	DCPA	EPTC	Norea	Sesone
Ajuga (*Ajuga* spp.)	R			R	
Begonia (*Begonia* spp.)		R			
Bleeding Heart (*Dicentra* spp.)		R			R
Bugleweed (*Lycopus* spp.)		S			
Calendula (*Calendula* spp.)	R				
Campanula (*Campanula* spp.)	R				
Chrysanthemum (*Chrysanthemum* spp.)		R		R	
Columbine (*Alquilegia* spp.)		R			R
Coralbell (*Heuchera Sangoinea*)	R	R			
Coreopsis (*Coreopsis* spp.)		R			
Cosmos (*Cosmos* spp.)		R			
Creeping Thyme (*Thyme* spp.)				R	
Cuphea (*Cuphea* spp.)		R			
Delphenium (*Delphenium* spp.)		R			
Evening Primrose (*Oenothera* spp.)		R			
Fescue (*Festuca* spp.)	R				
Feverfew (*Chrysanthemum parthenium*)		R			
Forgetmenot (*Myosotis* spp.)		R			
Four-o'clock (*Mirabilis* spp.)		R			
Foxglove (*Digitalis* spp.)		R			
Gaillardia (*Gaillardia* spp.)		R			
Gazania (*Gazania* spp.)	R				
Goldentuft (*Alyssum saxatile*)		R			
Ivy (*Hedera* spp.)	R		R		
Ivy, Boston (*Parthenocissus tricuspidata*)		R			
Ivy, English (*Hedera helix*)		R		R	
Larkspur (*Delphinium* spp.)					R
Lavender, cotton (*Santolina* spp.)		R			
Lily (*Lillium* spp.)		R			
Lily of the Valley (*Convallaria majalis*)					R
Lupine (*Lupinus* spp.)		R			
Morning glory (*Ipomoea* spp.)		R			
Mother-of-Thyme (*Thymus serpyllum*)		R			
Nasturtium (*Tropaeolum* spp.)		R			
Orpine (*Telephium* spp.)		R			
Pachysandra (*Pachysandra* spp.)	R	R	R		
Peony (*Paeonia* spp.)		R			
Periwinkle (*Vinca* spp.)	R			R	R
Phlox (*Phlox* spp.)		S			
Shasta Daisy (*Chrysanthemum maximum*)				R	
Stone crop (*Sedum* spp.)	R			R	
Sweet William (*Dianthus barbatus*)		S			
Yarrow Fernleaf (*Achillea filipendulin*)		R			

[1]R = Resistant
S = Susceptible

TABLE 12
Reaction of Some Ornamental Shrubs to Certain Herbicides

Name	Reaction[1] to									
	Bensulide	CDEC	DCPA	Dichlobenil	EPTC	Norea	Naptalam	Paraquat	Sesone	Simazine
Abelia (*Abelia* spp.)	R		R	R		R	R	R	R	R
Arbovitae (*Thuja* spp.)							R			
Azalea (*Azalea* spp.)	R	R	R	R			R			
Azara (*Azara* spp.)	R									
Barberry (*Berberis* spp.)			R	R						
Bayberry (*Myrica* spp.)									R	
Beautybush (*Kolkwitzia amabilis*)				R						
Boxwood (*Buxus* spp.)	R		R	R		S			R	
Buford holly (*Crenata burfordi*)						R				
Camellia (*Camellia* spp.)			R	R	R				R	
Cotoneaster (*Cotoneaster* spp.)			R	R						R
Daphne (*Daphne* spp.)	R									
Deutzia (*Deutzia* spp.)			R	R						
Eleagnus (*Eleagnus* spp.)			R							
Euonymus (*Euonymous* spp.)		R	R	R		R				
Firethorn (*Pyracantha* spp.)	R			R		R				
Flowering almond (*Prunus* spp.)				R						
Flowering quince (*Chaenomeles* spp.)				R						
Forsythia (*Forsythia* spp.)			R	R						
Gardenia (*Gardenia* spp.)				R						
Hawthorn (*Crataegus* spp.)			R							
Heather (*Calluna* spp.)				R					R	
Hibiscus (*Hibiscus* spp.)						S				
Holly (*Ilex* spp.)	R		R	R	R		R			
Honeysuckle (*Loniceva* spp.)			R	R						
Honeysuckle, bush (*L. tangutica*)									R	R
Hydrangea (*Hydrangea* spp.)		R	R						R	
Ivy English (*Hedera helix*)				R						
Japanese Andromeda (*Andromedia* spp.)			R			R				R
Japan Cleyera (*Cleyera Japonica*)				R						
Japanese holly (*Osmanthus delavali*)						R				
Juniper (*Juniperus* spp.)	R	R	R	R	R	R	R		R	R
Kinnikinnick (*Arctostaphylus uva-ursi*)				R						

TABLE 12 (Continued)
Reaction of Some Ornamental Shrubs to Certain Herbicides

Name	Reaction[1] to									
	Bensulide	CDEC	DCPA	Dichlobenil	EPTC	Norea	Naptalam	Paraquat	Sesone	Simazine
Ligustrum (*Ligustrum* spp.)						R				
Lantana (*Lantana* spp.)			R							
Laurel (*Laurus* spp.)				R					R	
Leucothoe (*Leocothoe* spp.)				R						
Lilac (*Syringa* spp.)			R	R			R		R	
Magnolia (*Magnolia* spp.)			R	R		R				
Mahonia (*Mahonia* spp.)									R	
Mountain Laurel (*Kalmia latitolia*)			R							
Myrtle (*Myrtus* spp.)	R									
Nandina (*Nandina* spp.)				R		R				
Olive (*Olea illicifolia*)				R						
Oregon Grape (*Mahonia aquifolium*)										R
Pachistima (*Pachistima* spp.)			R	R						
Peashrub (*Caragania* spp.)				R						R
Potentilla (*Cinquefoil* spp.)		R								
Pittosporum (*Pittosporum* spp.)			R	R						
Podocarpus (*Podocarpus* spp.)			R	R						
Privet (*Ligustrum* spp.)	R	R	R	R				R		
Rhododendron (*Rhododendron* spp.)			R	R		R		R		
Rockrose (*Cistus* spp.)				R						
Rose (*Rosa* spp.)			R	R					R	
Spirea (*Spiraea* spp.)		R	R	R		R			R	
Squawcarpet				R						
Star Jasmine (*Trachelospermum* spp.)	R									
Tobira	R									
Varigated Privet (*Ligustrum* spp.)			R							
Viburnum (*Viburnum* spp.)			R	R					R	
Weigela (*Weigela* spp.)			R	R						
Xylosma (*Xylosma* spp.)	R									
Yew (*Taxus* spp.)		R	R	R	R	R	R		R	R

[1]R = Resistant
S = Susceptible

TABLE 13
Reaction of Some Ornamental Trees to Herbicides

Name	Reaction[1] to								
	Bensulide	DCPA	Dichlobenil	EPTC	Naptalam	Norea	Paraquat	Sesone	Simazine
American elm (*Ulmus americiana*)									R
Amur corktree (*Phellodendron amorense*)			R						
Ash (*Fraxinus* spp.)		R					R		
Austrian pine (*Pinus nigra*)									R
Balsam fir (*Abies balsamea*)								R	R
Birch (*Betula* spp.)		R	R						
Blue spruce (*Picea* spp.)									R
Boxelder (*Acer negundo*)			R						R
Cedar (*Cedrus* spp.)					R				
Cherry (*Prunus* spp.)								R	
Chestnut (*Castanea* spp.)		R							
Citrus (*Citrus* spp.)								R	
Cottonwood (*Populus* spp.)		R	R		R				
Crabapple (*Malus* spp.)		R	R					R	
Cypress (*Cupressus* spp.)			R						
Dogwood (*Cornus* spp.)		R	R						R
Douglas fir (*Pseudotsuga* spp.)									R
Eastern red cedar (*Cedrus* spp.)			R						
Elm (*Ulmus* spp.)		R	R		R		R	R	
Fir (*Abies* spp.)		R		R			R	R	
Fir Fraser (*A. fraseri*)									R
Goldenraintree (*Koelreuteria* spp.)			R						
Green Ash (*Fraxinus pennsylvanica*)			R						
Gum (*Castilla* spp.)		R							
Hackberry (*Celtis* spp.)			R						
Hemlock (*Tsuga* spp.)				R		R		R	R
Honey locust (*Gleditsia* spp.)									R
Linden (*Tillia* spp.)			R						
Locust (*Robinia* spp.)		R	R						
Maple (*Acer* spp.)		R	R	R	R			R	
Mock orange (*Philadelphus* spp.)		R	R		R			R	
Monterey cypress (*Cupressys mocarpa*)	R								
Monterey pine (*Pinus radiata*)	R								

TABLE 13 (Continued)
Reaction of Some Ornamental Trees to Herbicides

Name	Reaction[1] to								
	Ben-sulide	DCPA	Di-chlo-benil	EPTC	Napta-lam	Norea	Para-quat	Se-sone	Sima-zine
Mountain ash (*Sorbus* spp.)			R						
Mugho pine (*Pinus mugo mughus*)									R
Norway spruce (*Picea notha*)									R
Oaks (*Quercus* spp.)		R	R	R			R		
Pine (*Pinus* spp.)		R	R	R	R	S	R	R	
Plum (*Prunus* spp.)					R			R	
Poplar (*Populus* spp.)		R	R						
Redbud (*Cercis* spp.)		R							
Red cedar (*Juniperus* spp.)								R	R
Red oak (*Quercus-rubra*)									R
Red pine (Norway) (*Pinus resinosa*)									R
Red spruce (*Picea rubens*)									R
Russian olive (*Elaeagnus angustifolia*)		R	R						R
Scotch pine (*Pinus sylvestris*)									R
Siberian elm (*Ulmus pumila*)									R
Spruce (*Picea* spp.)		R	R	R	R			R	
Sycamore (*Platanus* spp.)		R							
Tree peony (*Paeonia suffruticosa*)		R							
Tulip tree (*Liriodendron tulipfera*)		R							
Walnut (*Juglans* spp.)		R							
White birch (*Betula alba*)								R	
White cedar (*Chamaecyparis thyoides*)									R
White pine (*Pinus strobus*)									R
White spruce (*Picea alba*)									R
Willow (*Salix* spp.)		R							

[1]R = Resistant
S = Susceptible

TABLE 14
Herbicides for Weed Control in Lawns and Turf

Herbicide	Rate per acre[1]	Time of application	Weeds controlled	Remarks
Grass and broadleaf weeds				
Calcium cyanamide	2,200 lb.	3 weeks before seeding		Work into a moist and well prepared seed bed
DCPA	10 to 12 lb.	Early to mid-April	Crabgrass and many other annual grasses	For professional turf management; do not use on dichondra; do not seed for 3 months after treatment
Diphenamid	8 to 20 lb.	Fall and spring		For dichondra lawns
Endothall	2 lb.	When moisture favors good turf growth	Burclover, henbit, knotweed, pennywort	Temporary turf browning if air temperature is over 80°F., and dry
Metham	114 gal.	Preplanting		Put on well prepared and fine seed bed; can seal in with water without a cover; lasts about 2 weeks
Methyl bromide	454 lb.	When air and soil temperatures are above 65°F.	Most species	May seed 2 to 3 days after treatment; poisonous, extra precautions necessary
Methyl bromide + chloropicrin	500 to 600 lb.	-do-	Most species	Inject into the soil and cover with gas tight cover within 20 minutes; poisonous, extra precautions necessary; follow directions on label
Methyl isothiocynate + chlorinated C_3 hydrocarbons	28 to 57 gal.	-do-		Cover with gas tight cover for 1 week; poisonous, extra precautions necessary

TABLE 14 (Continued)
Herbicides for Weed Control in Lawns and Turf

Herbicide	Rate per acre[1]	Time of application	Weeds controlled	Remarks
Grass and broadleaf weeds – continued				
Paraquat	1 lb.	When weeds are in 3 to 5 leaf stage		Prepare seed bed first and let weed growth start; after treatment, seed with little soil disturbance; always use an appropriate surfactant
Grass weeds				
AMA	5 to 6 lb.	Summer	Mostly for crabgrass	If temperature is over 80°F. reduce rate of application
Benefin	2 to 3 lb.	Before germination of annual grasses		Do not use on bent-grass putting greens; may reseed within 3 months after treatment
Bensulide	10 to 20 lb.		Mostly for crabgrass	Apply to established turf only; do not overseed within 6 months after treatment
Dalapon	10 lb.	Through season on actively growing grass	Perennial grasses	Will injure all grasses; both spot treatment and preplant; repeat applications may be needed; seed lawn 3 to 4 weeks after last treatment
DSMA	3 to 6 lb.	Spring and early summer	Crabgrass, dallisgrass sandbur, foxtails, Johnsongrass seedlings and others; also, chickweed	May need 1 to 3 applications at 7 to 10 day intervals; do not use on St. Augustine or centipede grass
MSMA	3 to 6 lb.	-do-	-do-	-do-
Petroleum naptha	44 gal.	When grasses are in active growth	Clumps of some grass weeds	Use with care as a direct spray; will injure lawn grasses

TABLE 14 (Continued)
Herbicides for Weed Control in Lawns and Turf

Herbicide	Rate per acre[1]	Time of application	Weeds controlled	Remarks
		Grass weeds – continued		
Siduron	10 lb.	Before weed seeds germinate	Does not control annual bluegrass; will control crabgrass, foxtails, and downy brome grass	Treat before, after, or during seeding, water within 3 days if it does not rain; use on bluegrass and fescue lawns; check susceptibility on other lawn species
Terbutol	10 to 20 lb.	Before germination	For crabgrass control	Use in established lawns; do not overseed within 6 months after treatment
		Broadleaf weeds		
Dicamba	1/2 to 1 lb.	When weeds are in active growth	Red sorrel, knot weed, clovers, chickweed, and others	Keep away from root zone of trees and ornamentals; usually mixed with 2,4-D for spraying; use no more than 1/4 lb./A in lawns
Silvex	3/4 to 1 lb.	While weeds are small	Especially chickweed, ground ivy, and henbit	Apply when there is ample moisture and air temperature of 75°F. or more
2,4-D	1 to 1-1/2 lb.	When weeds are in active growth	Many species	Choose bright days with temperature near 70°F.; do not mow for 24 to 48 hours
2,4-D amine salt or low volatile ester plus detergent	1 to 2 lb.	Late winter or early spring	Knotweed, wild garlic, and wild onion	Follow directions on label; repeated annual treatments for wild garlic

TABLE 14 (Continued)
Herbicides for Weed Control in Lawns and Turf

Herbicide	Rate per acre[1]	Time of application	Weeds controlled	Remarks
Broadleaf weeds – continued				
2,4-D plus dicamba or silvex	0.25 + 2 lb.	When weeds are small	Chickweed, clover, henbit, knotweed, and red sorrel	Do not exceed recommended rate; protect trees, shrubs, and flowers by spraying in root zone of shrubs; prevent drift

[1]Pounds of active ingredient.

and tastes are produced in drinking water. Filamentous algae produce threadlike or surface scums that interfere with fishing, and plug underwater screens and sprinkler systems. Some algae grow on submerged rocks, and bottoms and walls of concrete swimming pools, making them slippery and hazardous for waders and swimmers.

Also considered is whether the herbicide is harmful to fish, to livestock, or wildlife that drink the treated water, or to crops irrigated with treated water. In addition special precautions must be observed if the water is to be subsequently treated and used for human consumption. Normally, the chemical of choice in or near potable water is copper sulfate or dalapon. Other compounds should not be used without prior approval of a medical officer.

All of these factors have been taken into account in the suggested herbicide uses described in Table 15. Grouped together are aquatic plants of a similar growth habit such as emersed, floating, and submersed; and plants that grow in the same environments—such as ditchbanks; ponds, lakes, and reservoirs; irrigation and drainage canals (flowing water and reservoirs, and canals carrying potable water).

Herbicide residues are subject to change on the basis of new information on persistence of residues, toxicity to fish, etc. Labels on herbicide packages should be kept up-to-date on such changes. The user of an aquatic weed control herbicide must read the label carefully to make certain he is using the correct herbicide.

TABLE 15
Herbicides To Control Aquatic Weeds

Herbicide	Rate of application[1]	Time of application	Weeds controlled	Remarks
Perennial sedges on irrigation and drainage ditchbanks				
Amitrole or amitrole-T	5 to 20 lb./A	On young growth before heading	Tall sedges	Repeat every 6 to 8 weeks as needed; use only in drainage ditches or marshes; do not contaminate irrigation or potable water supplies
Dalapon	15 lb/A	On young growth 10 to 15" tall	-do-	Repeat every 6 to 8 weeks as needed; may be used in water supply reservoirs provided the concentration does not exceed 0.1 mg/1 in the reservoir; may be used in irrigation water provided the sodium content of the irrigated soil is not critical.
Fuel oil with dinoseb	100 to 160 gal./A	-do-	-do-	Use 2 to 3 pts. of dinoseb per 100 gal. of fuel oil; avoid contamination of irrigation or potable water
2,4-D	6 to 8 lb./A	-do-	-do-	Repeat as necessary; avoid contamination of irrigation or potable water
Floating weeds (unattached, tops above water)				
Amitrol-T	1 to 1.5 lb./A	When actively growing	Water hyacinth	Use only in drainage ditch or marshes; do not use treated water for domestic or irrigation purposes except as specified on the label
Diquat (cation)	0.5 to 1 p.p.m. 1 to 1.5 lb./A	Time of active growth	Duckweed, water hyacinth, water lettuce	Inject in water or spray on foliage; do not use treated water for ten days after treatment
Silvex (ester)	8 lb./A	At first bloom	Alligatorweed	Repeat, 2 to 4 applications as needed; do not use treated water for domestic purposes except as specified on the label
2,4-D amine salts	2 to 4 lb./A	When weeds are in active growth	General control alligatorweed, duckweed, waterfern, water lettuce	Repeat every 4 to 5 weeks as needed; include oil and emulsifier for duckweed and water lettuce. Do not use treated water except as specified on the label

TABLE 15 (Continued)
Herbicides To Control Aquatic Weeds

Herbicide	Rate of application[1]	Time of application	Weeds controlled	Remarks
Emersed and marginal weeds (rooted under water, tops above water, or growing on wet soil)				
Amitrole	6 to 12 lb./A	Fully headed or post heading stage	Bulrushes and cattails	Use only in drainage ditches or marshes; do not use contaminated water for domestic or irrigation purposes
Amitrole or amitrole-T	8 to 16 lb./A	On young growth before heading	Perennial grasses and sedges	Apply in 100 to 400 gal. water as a ground spray; 10 to 15 gal. water as an aerial spray; use only in drainage ditches or marshes; do not use treated water for domestic or irrigation purposes
Dalapon	15 to 30 lb./A	-do-	Cattails	Apply in 100 to 400 gal. water as a ground spray; 10 to 15 gal. water as an aerial spray; may be used in water supply reservoirs provided the concentration does not exceed 0.1 mg/1 in the reservoir; may be used in irrigation water provided the sodium content of the irrigated soil is not critical.
	20 to 30 lb./A	-do-	Perennial grasses and sedges	
Silvex (ester)	8 lb./A	At first bloom	Rooted, emersed alligatorweed	Apply 2 to 4 applications as needed in 150 to 200 gal. water per acre; do not use treated water for domestic or irrigation purposes except as specified on label
2,4-D (low-volatile esters)	4 to 6 lb./A	At first heading	Bulrushes and cattails	Apply in 1:20 oil-water emulsion at 150 to 200 gal. per acre; precautions as above
2,4-D (low-volatile esters)	1 to 4 lb./A	-do-	Arrowhead, white water lily, and other plants with waxy leaves	Apply in oil or oil-water emulsion (1:10 or 1:20); precautions as above
2,4-D, or silvex	2 to 4 lb./A	When weeds are actively growing	General for broad-leaf weeds	Spray in 200 gal. water per acre; precautions as above

TABLE 15 (Continued)
Herbicides To Control Aquatic Weeds

Herbicide	Rate of application[1]	Time of application	Weeds controlled	Remarks
Submersed weeds (tops mostly under water, usually rooted or anchored) In ponds, lakes, and reservoirs				
Copper sulfate (pentahydrate, dark blue)	0.1 to 0.5 p.p.m.w.	Early stage of growth	Algae, blue-green	Apply as crystals or powder; repeat as necessary
Copper Sulfate	0.5 to 1 p.p.m.w.	-do-	Algae, filamentous	In soft water, safe on most fish except trout; safe in potable water
Copper sulfate (pentahydrate, dark blue)	1 to 2 p.p.m.w.	-do-	-do-	In hard water, injurious to most fish; safe in potable water
Dichlobenil	7 to 10 lb./A	-do-	Rooted or anchored weeds	Follow directions on label. Do not use treated water for domestic or irrigation purposes.
	10 to 15 lb./A	When new growth starts	-do-	Broadcast on water surface; use heavier rate if water is more than 3' deep
Diquat (cation)	0.5 to 1.5 p.p.m.w.	-do-	Rooted or anchored weeds except elodea and wild celery	Apply on the surface or inject below; do not use treated water for domestic or irrigation purposes for 10 days after treatment
Endothall (diemthylaikylamine salts)	0.05 to 0.2 p.p.m.w.	-do-	Filamentous algae	Apply on the surface or inject below; do not use treated water for domestic or irrigation purposes for 7 days after treatment
	0.5 to 2.5 p.p.m.w.	-do-	Rooted or anchored weeds except chara	For spot treatment or where some fish kill is not objectionable; precautions as above
Endothall (disodium salt)	1 to 4 p.p.m.w.	-do-	-do-	Consult fish and wild life specialists before use; precautions as above

TABLE 15 (Continued)
Herbicides To Control Aquatic Weeds

Herbicide	Rate of application[1]	Time of application	Weeds controlled	Remarks
Submersed weeds (tops mostly under water, usually rooted or anchored) In Ponds, Lakes, and Reservoirs – continued				
Fenac	15 to 20 lb./A	When lake bottom or shorelines are exposed	-do-	Keep water down for at least 3 weeks; do not use treated water for domestic or irrigation purposes
2,4-D (ester) (granule or pellet form)	20 to 40 lb./A	-do-	-do- except elodea, wild celery, and some pond weeds	Toxic to some fish; apply to surface of water. Do not use treated water for domestic or irrigation purposes.
Silvex (potassium salt)	1.5 to 2 p.p.m.w. or 5 lb./A. ft.	-do-	-do-	Apply to surface or inject below water surface. Do not use treated water for domestic or irrigation purposes.
Irrigation and drainage canals–flowing water				
Acrolein	1 to 2.5 gal. c.f.s.	When weed infestation starts	All species of algae and submersed weeds	Use special equipment; apply below surface; toxic to fish; do not use treated water for domestic purposes
	0.1 to 0.6 p.p.m.w.	-do-	-do-	Inject into large canals (200 to 2,000 or more c.f.s.) at one location for 8 to 48 hours
Aromatic solvents (xylene)	8 to 10 gal. c.f.s. (300 to 740 p.p.m.w. in 30 to 60 minutes)	Before weeds become matted	Most submersed species except water plantain	Avoid fire hazard; treat water at intervals of 2 to 4 miles down canal. Do not use treated water for domestic purposes.
Irrigation and drainage canals–flow stopped or greatly reduced				
Acrolein	4 to 7 p.p.m.w.	-do-	-do-	Apply below surface; toxic to fish; do not use treated water for domestic purposes

TABLE 15 (Continued)
Herbicides To Control Aquatic Weeds

Herbicide	Rate of application[1]	Time of application	Weeds controlled	Remarks
Irrigation and drainage canals–flow stopped or greatly reduced – continued				
Diquat (cation)	0.25 to 1.5 p.p.m.w.	When weed starts to grow	Most submersed weeds	Apply above or below surface; allow at least 12 hours exposure; do not use treated water for domestic or irrigation purposes for 14 days after treatment
Endothall (dimethylaikylamine salt)	1.5 to 4 p.p.m.w.	-do-	-do-	Apply above or below surface; toxic to fish; do not use treated water for domestic or irrigation purposes for 14 days after treatment
Reservoirs and large canals carrying potable water				
Copper Sulfate (pentahydrate)	0.6 to 1 p.p.m.w.	Continuous during growing season	Most algae and submersed weeds	Heavy applications early in season; reduce as water temperature rises
"Slug" treatments	0.33 to 2 lb./c.f.s.	Periodically during growing season	-do-	Light rates for soft water; crystals dissolve very slowly; may be suspended in burlap bags

[1]Rates and concentrations are in terms of acid equivalent or active ingredient, and not necessarily, or usually, of commercial formulation.

Section 4. WEED SPECIES AND HERBICIDES FOR THEIR CONTROL

The response of weeds and some crops to herbicides is given in Table 16.

The weeds are listed in alphabetical order by common names. Genus, species, and, in some instances, variety are given where response to herbicides is specific and information is available.

In the "Response to herbicides" column, S means susceptible, I means intermediate, and R means resistant. S and I represent ranges in response. The response of a plant to an application of herbicide depends not only on the species but also on the age of the plant, the rate of herbicide used, and the soil and climatic environment in which the plant is grown. Seedlings are killed most easily—even seedlings of some resistant species are killed. Many plants become more tolerant to an herbicide as they grow older. Some perennials are most easily killed when in bloom. Woody plants may be more susceptible to one method of application than to another. A weed described as S to an herbicide may vary from a susceptible reaction if treated at the optimum time, with the optimum rate, and under the optimum environment to a more tolerant reaction under conditions less favorable for control. A weed described as I may vary from tolerant to resistant; its response depends on age when treated, rate of herbicide used, and environmental conditions.

When a weed is susceptible (S), it can be killed with moderate rates of an herbicide. If it is intermediate in reaction (I), it is severely injured or partially controlled by higher rates. If it is resistant (R), control with the herbicide is not feasible.

The list of chemicals to which the response of a weed species is listed as S or I or R is not complete. The absence of any chemical from the list does not imply that it could not be used or that it should not be used. Its absence means only that it has not been tried sufficiently or in direct comparison with other chemicals by impartial investigators at this time (1968). Additions to the list can be made when such information becomes available.

TABLE 16
Weed Species and Herbicides for Their Control

(A, annual; Aq, aquatic; B, biennial; P, perennial; W, woody; S, susceptible; I, intermediate; R, resistant; *, toxic to fish in concentrations required to control weeds)

Weed species	Growth habit	Response to herbicide	Herbicide
Absinthe (see wormwood)			
African-rue (*Peganum harmala*)	P	I	Silvex; 2,4,5-T
Agrimony (*Agrimonia gryposepala*)	P	R	2,4-D
Alder: (*Alnus* spp.)	W	S	2,4-D + TCA; 2,4,5-T + TCA
speckled (*A. rugosa*)	W	S	AMS; fenuron; silvex; 2,4-D; 2,4,5-T
Algae			
bluegreen (many genera)	Aq	S–I	Copper sulfate
green			
nonfilamentous	Aq	S–I	Copper sulfate
filamentous			
(*Chara*)	Aq	S	Dichlobenil
		I	Copper sulfate, diquat, endothall (dimethylamines)*
(*Cladophora, hydrodictyon, spirogyra,* et al)	Aq	S	Copper sulfate, diquat, endothall (amine salts*, simazine)
(*Pithophora*)	Aq	S	Endothall (amine salts)*, silvex, simazine
		R	Copper sulfate, monuron
Alligatorweed (*Alternanthera philoxeroides*)	Aq	I	Silvex; 2,4-D
		R	Amitrole
Alyssum, hoary (*Beteroa incana*)	B or P	S	Amitrole; 2,4,5-T
		I	2,4-D
Amaranth (see *pigweed*)			
Ammannia, purple (*Ammannia coccinea*)	A	S	Silvex; 2,4-D; 2,4,5-T
Arrowgrass, seaside (*Triglochin maritima*)	P	I	2,4-D; 2,4,5-T
Arrowhead			
California (*Sagittaria calycina*)	Aq	S–I	Diquat; silvex; 2,4-D; 2,4,5-T
longbarb (*S. longiloba*)	Aq	S	Diquat; silvex
		I	2,4-D
		R	2,4,5-T
Artichoke (*Cynara scolymus*)	P	S	Fortified oil
		R	2,4-D; 2,4,5-T

TABLE 16 (Continued)
Weed Species and Herbicides for Their Control

Weed species	Growth habit	Response to herbicide	Herbicide
Ash (*Fraxinus*, spp.)	W	I–R	Amitrole; dicamba + 2,4-D or 2,4,5-T; fenac
		I	AMS
		R	Fenuron; silvex; 2,4-D; 2,4,5-T
Aspen (*Populus* spp.)	W	S–I	AMS: fenuron; picloram + borate; picloram + 2,4-D; 2,4,5-T
		I	Amitrole; 2,3,6-TBA
trembling (*P. tremuloides*)	W	S–I	AMS; fenuron; 2,4-D; 2,4,5-T; 2,4-D + TCA; 2,4,5-T + TCA
		I	Amitrole; 2,3,6-TBA
Aster			
(species not designated)	P	S	Bromacil
heath (*Aster ericoides*)	P	S	2,4-D
purple-stemmed (*A. pruniceus*)	P	S	Atrazine
western (*A. occidentalis*)	P	R	Silvex; 2,4-D; 2,4,5-T
white heath (*A. pilosus*)	P	I	Silvex; 2,4-D; 2,4,5-T
woody (*A. parryi*)	P	R	Silvex; 2,4-D; 2,4,5-T
Baccharis (see coyotebrush) (*Baccharis* spp.)	W	S	Chlorpropham; DSMA; MSMA; silvex; simazine; trifluralin; 2,4-D; 2,4,5-T
eastern (*B. halimifolia*)	W	S	2,4-D; 2,4,5-T
		R	Norea
Baileya, desert (*Baileya multiradiata*)	P	S	2,4-D; 2,4,5-T
Ballmustard (*Neslia paniculata*)	A	S	2,4-D
Balsam (*Impatiens* spp.)	W	S	Picloram + 2,4-D; 2,4,5-T
Barberry			
American (*Berberis*	W	I	2,4,5-T
canadensis)	W	I–R	Simazine; 2,4-D
Colorado (*B. fendleri*)	W	S	2,4-D
Barley, foxtail (*Hordeum jubatum*)	A	S	Dalapon
Barnyard grass (*Echinochloa*) *crusgalli*)	A	S	AMA, atrazine, benefin, bensulide, CDEC, chlorpropham, dalapon, DCPA, diphenamid, DSMA, EPTC, MSMA, naptalam, norea, prometryne, sesone, siduron, simazine, TCA, terbacil, trifluralin
		R	Silvex; 2,4-D; 2,4,5-T

TABLE 16 (Continued)
Weed Species and Herbicides for Their Control

Weed species	Growth habit	Response to herbicide	Herbicide
Bassia, fivehook (*Bassia hyssopifolia*)	A	I	2,4-D
Basswood, American (*Tilia americana*)	W	I	Dicamba + 2,4-D; or 2,4,5-T; fenac
	W	I	AMS; 2,4,5-T
	W	R	2,4-D
Bearberry (*Arctostaphylos uvaursi*)	W	I	2,4,5-T
Bearmat (*Chamaebatia foliolosa*)	W	S	2,4-D; 2,4,5-T
Bedstraw			
catchweed (*Galium aparine*)	A	S	Dinoseb, monuron, silvex
	A	I–R	2,4-D; 2,4,5-T
white (*G. mollugo*)	P	S	Silvex
	P	R	2,4-D; 2,4,5-T
Beech (*Fagus*, spp.)	W	S–I	AMS
	W	I–R	2,4-D; 2,4,5-T
Beeplant, Rocky Mountain (*Cleome serrulata*)	A	I	2,4-D
Beggarticks (*Bidens frondosa* and *B. vulgata*)	A	S	Silvex; 2,4-D; 2,4,5-T
Bellflower, creeping (*Campanula rapunculaides*)	P	S	2,3,6-TBA
Bellwort, common (*Colchicum autumnale*)	P	I	2,4-D
Bermuda grass (*Cyndon dactylon*)	P	S	Bromacil, dalapon, EPTC (seedlings only), herbicidal oils and fumigants, terbacil
	P	I–R	Amitrole, atrazine, BMM, CBM, CBMM, diuron, monuron, simazine, TCA
	P	R	CDEC; chlorpropham; DCPA; DSMA; MSMA; prometryne; silvex; 2,4-D; 2,4,5-T
Betony, Florida (*Stachys floridana*)	P	I–R	2,4-D; 2,4,5-T
Bindweed			
(species not designated)	P	S	Dichlobenil, naptalam
field (*Convolvulus arvensis*)		S	Atrazine; dicamba; fenac; picloram + borate; picloram

TABLE 16 (Continued)
Weed Species and Herbicides for Their Control

Weed species	Growth habit	Response to herbicide	Herbicide
Bindweed field (con.)			+ 2,4-D; sodium chlorate; 2,3,6-TBA
		I	CBM; CBMM: diuron; monuron; silvex; 2,4-D; 2,4,5-T
		R	Amitrole, amitrole-T; CDEC, chlorpropham, erbon, simazine
hedge (*C. sepium*)	P	S–I	Atrazine; 2,4-D; 2,4,5-T
Birch (*Betula* spp.)	W	S	AMS; fenuron; picloram + 2,4-D; 2,4,5-T
	W	S–I	2,4-D
Birdrape, mustard (*Brassica rapa*)	B	S	Silvex; 2,4-D; 2,4,5-T
Biscuitroot, bicolor (*Lomatium leptocarpum*)	P	S–I	2,4,5-T
	P	I	2,4-D
Bistort, American (*Polygonum bistortoides*)	P	I	2,4-D; 2,4,5-T
Bittercress (*Cardamine* spp.)	Aq	S	2,4-D
Bitter sneezeweed or Bitterweed (*Helenium tenuifolium*)	A	S	AMS ; silvex; 2,4-D; 2,4,5-T
	A	R	TCA
Blackberry (*Rubus* spp.)	W	S–I	AMS: fenuron; picloram + borate; picloram + 2,4-D; 2,4,5-T; 2,3,6-TBA
	W	I	Amitrole; monuron; silvex; sodium chlorate
	W	R	Simazine; 2,4-D
Black-eyed-susan (*Rudbeckia serotina*)	P	S	Atrazine; silvex; 2,4-D; 2,4,5-T
Bladderwort (*Utricularia* spp.)	Aq	S–I	Acrolein*, aromatic solvents*, diquat, endothall (amine)*
Blessed thistle (*Cnicus benedictus*)	A	S	2,4-D
Bluebell (*Campanula rotundifolia*)	P	S	2,3,6-TBA
		R	2,4-D
Bluebur (see stickseed or sticktight, European)			
Bluegrass (*Poa* spp.)	P	S	Atrazine
annual (*P. annua*)	A	S	Benefin, bensulide, CDEC,

TABLE 16 (Continued)
Weed Species and Herbicides for Their Control

Weed species	Growth habit	Response to herbicide	Herbicide
Bluegrass annual (con.)			chlorpropham, DCPA, dichlobenil, diphenamid, EPTC, paraquat, terbacil, trifluralin, simazine
		R	Terbutol, siduron
Bluemustard (*Chorispora tenella*)	A	S	Silvex; 2,4,5-T
		I	2,4-D
Bluestem, little (*Andropogon scoparius*)	P	S	Atrazine
		I	Fenuron; 2,3,6-TBA
		R	Silvex; 2,4-D; 2,4,5-T
Blue thistle (*Echium vulgare*)	B	I	2,4-D; 2,4,5-T
Blueweed, Texas (*Helianthus ciliaris*)	P	S	AMS; amitrole; fenuron; 2,3,6-TBA
		I	2,4-D
		R	Silvex
Bouncing-bet (*Saponaria officinalis*)	P	S	Bromacil
		R	Silvex; 2,4-D; 2,4,5-T
Boxelder (*Acer negundo*)	W	S	Fenuron; silvex; 2,4-D; 2,4,5-T
Bracken (*Pteridium aquilinum*)	P	S	Amitrole, AMS, bromacil; CBM
		I	BDM, BMM, monuronTCA
		R	Dalapon; diuron; erbon; fenac; monuron; silvex; sodium chlorate; 2,4-D
Brambles (*see blackberry*)			
Briers (*see smilax*)			
Bristlegrass (*see foxtail*)			
Bromegrass	P	R	Silvex; 2,4-D; 2,4,5-T
(species not designated)	P	S	Bromacil; trifluralin
smooth (*Bromus inermis*)	P	S	Bromacil
downy (*B. tectorum*)	P	S	Atrazine, chlorpropham, dalapon, diphenamid, diuron, endothall, monuron, simazine, TCA
		R	DCPA; silvex; 2,4-D; 2,4,5-T
Broomsedge (*Andropogon virginicus*)	P	S	Atrazine; bromacil
		I	Dalapon
		R	Silvex; 2,4-D; 2,4,5-T; 2,3,6-TBA

TABLE 16 (Continued)
Weed Species and Herbicides for Their Control

Weed species	Growth habit	Response to herbicide	Herbicide
Broomweed			
common (*Gutierrezia dracunculoides*)	A	S	Silvex; 2,4-D; 2,4,5-T
threadleaf (*G. microcephala*)	P	S	Silvex; 2,4-D; 2,4,5-T
Browntopmillet (*Panicum ramosum*)	A	S	DCPA
Buckbrush (*Symphoricarpos orbiculatus*)	W	S	AMS; fenuron; 2,4-D
	W	I	2,4,5-T; 2,3,6-TBA
	W	R	Silvex
snowberry, western (*S. occidentalis*)	W	S	AMS; fenuron
	W	I	2,4-D; 2,3,6-TBA
		R	Silvex; 2,4,5-T
Buckeye			
Texas (*Aesculus arguta*)	W	I	AMS
	W	R	Silvex
California (*A. californica*)	W	I	2,4-D
	W	R	Silvex; 2,4,5-T
Buckthorn			
California (*Rhamnus californica*)	W	I	2,4-D
Carolina (*R. caroliniana*)	W	R	Fenuron
Buckwheat			
tartary (*Fagopyrum tataricum*)	A	S	Chlorpropham, dicamba, endothall
		I	Silvex; 2,4,5-T
		R	2,4-D
wild (see wild buckwheat)			
Buffalobur (*Solanum rostratum*)	A	R	Benefin; diphenamid; silvex; trifluralin; 2,4-D; 2,4,5-T
Bugle, carpet (*Ajuga reptans*)	P	R	2,4-D
Bugleweed, American (*Lycopus americanus*)	P	S	2,4-D
Bullnettle (*Cnidoscolus stimulosus*)	P	S	DSMA; 2,4-D; 2,4,5-T
		I	Simazine
Bullthistle (*Cirsium vulgare*)	B	S	Picloram; silvex; 2,4-D; 2,4,5-T
Bulrush (*Scirpus* spp.)	Aq	S–I	Amitrole; MSMA; silvex; 2,4-D; 2,4,5-T
		R	Copper sulfate
Bumelia, gum (*Bumelia lanuginosa*)	W	S	Silvex; 2,4,5-T

TABLE 16 (Continued)
Weed Species and Herbicides for Their Control

Weed species	Growth habit	Response to herbicide	Herbicide
Burclover, California (*Medicago hispida*)	A	S	Endothall, paraquat, silvex
Burcucumber (*Sicyos angulatus*)	A	S	2,4,5-T
		I	2,4-D
Burdock			
common (*Arctium minus*)	B	S	Atrazine; silvex; 2,4-D 2,4,5-T
	B	R	MonuronTCA
great (*A. lappa*)	B	I	2,4-D
	B	R	Diuron; monuron; monuronTCA
Burhead (*Echinodorus cordifolius*)	A	S	Silvex; 2,4-D; 2,4,5-T
Burnet (*Poterium sanguisorba*)	P	R	2,4-D
Burning-bush (see kochia)			
Burreed, threesquare (*Sparganium americanum*)	Aq	S	Endothall; diuron; monuron; 2,4-D
	Aq	I	Dalapon, silvex
Burroweed (*Haplapappus tenuisectus*)	P	S	2,4-D; 2,4,5-T
Bursage			
skeletonleaf (*Franseria discolor*)	P	S	Amitrol fenac; 2,3,6-TBA
		I	Silvex; 2,4-D; 2,4,5-T
slimleaf (*F. confertiflora*)	P	R	Silvex; 2,4-D; 2,4,5-T
wollyleaf (*F. tomentosa*)	P	S	Amitrole; fenac; 2,3,6-TBA
		I	Silvex; 2,4-D; 2,4,5-T
Bush-honeysuckle (*Diervilla lonicera*)	W	S	2,4-D
Buttercup	A,B, or P		
bulbous (*Ranunculus bulbous*)	P	R	2,4-D
celeryleaf (*R. scleratus*)	A	I	2,4-D
corn (*R. arvensis*)	A	S	Silvex; 2,4-D; 2,4,5-T
creeping (*R. repens*)	P	S	Monuron; silvex; sodium chlorate; 2,4-D; 2,4,5-T
	P	R	Simazine
small flower (*R. abortivus*)	A or B	S	2,4-D
tall (*R. acris*)	P	S	Silvex; 2,4-D; 2,4,5-T
Buttonbush, common (*Cephalanthus occidentalis*)	W	S	Picloram
		I–R	AMS; silvex; 2,4-D; 2,4,5-T
Cactus, pricklypear (*Opuntia* spp.)	W	I	Silvex; 2,4,5-T; 2,3,6-TBA

TABLE 16 (Continued)
Weed Species and Herbicides for Their Control

Weed species	Growth habit	Response to herbicide	Herbicide
Calendula (*Calendula* spp.)	A	R	Silvex, 2,4-D
Camelthorn (*Alhagi camelorum*)	P	I	2,3,6-TBA; 2,4,5-T
	P	R	Sodium chlorate
Camphorweed (*Heterotheca subaxillaris*)	A or B	I	2,4-D
Campion			
bladder (*Silene cucubalus*)	P	R	Silvex; 2,4-D; 2,4,5-T
red (*Lychnis dioica*)	B or P	R	2,4-D; 2,4,5-T
Canary grass, reed (*Phalaris arundinacea*)	P	S	Amitrole-T, atrizine, bromacil, dalapon
	P	I	Monuron, simazine
Caragana or pea-tree (*Caragana arborescens*)	W	S	Monuron; 2,4,5-T
	W	I	AMS, diuron, simazine
Caraway (*Carum caryi*)	B	I	2,4-D; 2,4,5-T
	B	R	Amitrole, silvex
Carelessweed (see pigweed, Palmer)			
Carpetgrass (*Axonopus affinus*)	P	S	Amitrole
Carpetweed (*Mollugo verticillata*)	A	S	Atrazine; benefin; chlorpropham; DCAP, dichlobenil; diphenamid; naptalam; trifluralin; sesone; simazine; 2,4-D
		R	Silvex; 2,4,5-T
Carrot, wild (*Daucus carota*)	B	S	AMS; atrazine; bromacil; picloram + 2,4-D
		I	MonuronTCA; silvex; 2,4-D; 2,4,5-T
		R	Diuron, dinoseb, fenac, monuron
Catbrier (see smilax)			
Catchfly			
hairy (*Silene dichotoma*)	A	R	2,4-D
nightflowering (*S. noctiflora*)	A	R	Dicamba; endothall; silvex; 2,4-D; 2,4,5-T
sleepy (*S. antirrhina*)	A	R	2,4-D
Catclaw, mimosa (*Mimosa biuncifera*)	W	I	2,4,5-T
Catnip (*Nepeta cataria*)	P	S	2,4-D; 2,4,5-T

TABLE 16 (Continued)
Weed Species and Herbicides for Their Control

Weed species	Growth habit	Response to herbicide	Herbicide
Catsear, spotted (*Hyochoeris radicata*)	P	S	Silvex; 2,4-D; 2,4,5-T
Cattail (*Typha* spp.)	Aq	S	Amitrole; amitrole-T; dalapon; 2,4-D esters
Ceanothus			
deerbrush (*Ceanothus integerrimus*)	W	S	2,4-D
Jerseytea (*Ceanothus americanus*)	W	R	CBM, CBMM
varnishleaf (*C. velutinus var. laevigatus*)	W	S	2,4,5-T
wedgeleaf (*C. cuneatus*)	W	S	2,4-D; 2,4,5-T
Centipede grass (*Eremochloa ophiuroides*)	P	S	TCA
Chamise (*Adenostoma fasciculatum*)	W	I	2,4-D; 2,4,5-T
	W	R	Silvex
Chamomile			
corn (*Anthemis arvensis*)	A or B	R	2,4-D
false (*Matricaria maritima*)	A	S	Amitrole, sodium chlorate
		R	2,4-D
mayweed (*A. cotula*)	A	I	Atrazine; silvex, 2,4-D; 2,4,5-T
Charlock (see mustard, wild)			
Cheat or chess (*Bromus secalinus*)	A	S	Bromacil, diphenamid, trifluralin
		R	DCPA: paraquat; simazine; 2,4-D; 2,4,5-T
Cherry (*Prunus* spp.)	W	S	AMS: dicamba + 2,4-D or 2,4,5-T; fenuron; picloram + 2,4-D
		I	Silvex; 2,4,5-T; 2,3,6-TBA
		R	Amitrole; 2,4-D
Chestnut (*Castanea* spp.)	W	S	AMS; fenuron
		I	2,4,5-T
Chickweed			
(species not designated)	A	S	Dichlobenil; DSMA; naptalam; paraquat; sesone; terbacil
common (*Stellaria media*)	A	S	Atrazine; benefin; CDEC; chloropropham; dicamba; dichlobenil; DCPA; diphenamid; dinoseb; EPTC; monuron; norea; silvex;

TABLE 16 (Continued)
Weed Species and Herbicides for Their Control

Weed species	Growth habit	Response to herbicide	Herbicide
Chickweed (con.)			
common			simazine; sodium chlorate; trifluralin; 2,4,5-T
		I	2,4-D
		R	Endothall
field (*Cerastium arvense*)	P	S	MSMA; silvex; 2,4,5-T
		I	2,4-D
mouse-ear (*C. vulgatum*)	P	S	Dicamba, silvex
		I	2,4-D; 2,4,5-T
		R	Dinoseb, endothall
Chicory (*Cichorium intybus*)	P	S	Silvex; 2,4-D; 2,4,5-T
Chinquapin			
California (*Castanopsis sempervirens*)	W	I	2,4-D; 2,4,5-T
golden (*C. chrysophylla*)	W	R	Amitrole; silvex; 2,4-D; 2,4,5-T
Chokecherry (see cherry)			
Cholla, jumping	W	S	Silvex; TCA
(*Opuntia fulgida*)		I	2,4,5-T
Christmasberry (*Photinia arbutifolia*)	W	S	2,4-D
		I	Silvex; 2,4,5-T
Cinquefoil			
blueleaf (*Potentilla diversifolia*)	P	I	2,4-D; 2,4,5-T
common (*P. canadensis*)	P	S	2,4-D
		I	Silvex; 2,4,5-T
creeping (*P. reptans*)	A	S	Atrazine
rough (*P. norvegica*)	A or B	S	Chlorpropham; 2,4-D
silverweed (*P. anserina*)	P	I	2,4-D
sulfur (*P. recta*)	P	S	2,4-D; 2,4,5-T
		I	Silvex
Cleavers (see bedstraw, catchweed)			
Clover, red (*Trifolium pratense*)	B	S	Picloram + 2,4-D
sweet (*Melilotus* spp.)	B	S	Picloram + 2,4-D
Cockle, white (*Lychnis alba*)	P	S	Dicamba; 2,3,6-TBA
		R	2,4-D; 2,4,5-T
Cocklebur, common (*Xanthium pennsylvanicum*)	A	S	Atrazine; DSMA; MSMA; naptalam; norea; prometryne; 2,4-D; 2,4,5-T
		I	Benefin; monuronTCA

TABLE 16 (Continued)
Weed Species and Herbicides for Their Control

Weed species	Growth habit	Response to herbicide	Herbicide
Cocklebur, common (con.)		R	Chlorpropham; diphenamid; diuron; herbicidal oils; monuron; trifluralin
Coffeetree, Kentucky (*Gymnocladus dioicus*)	W	S	AMS
		I	2,4,5-T
Coffeeweed (*Daubentonia texana*)	A	S	DSMA; MSMA; silvex; 2,4,5-T
Coltsfoot (*Tussilago farfara*)	P	S	Sodium chlorate
	P	I	2,4-D
	P	R	Diuron, monuron
Comfrey, common (*Symphytum officinale*)	P	R	2,4-D
Coneflower, tall (*Rudbeckia laciniata*)	P	S	Silvex; 2,4-D; 2,4,5-T
Conifers (species not designated)	W	S	Picloram + borate
Coontail, common (*Certophyllum demersum*)	Aq	S	Acrolein*; aromatic solvents; diquat; endothall; dipotassium or disodium; silvex; simazine; 2,4-D
		R	Copper sulfate
Coralberry (see buckbrush)			
Coreopsis, plains (*Coreopsis tincloria*)	A	S	2,4-D; 2,4,5-T
Coriander (*Coriandrum sativum*)	A	R	2,4-D
Corncockle (*Agrostemma githago*)	A or B	R	Silvex; 2,4-D; 2,4,5-T
Cornflower (*Centaurea cyanus*)	A	S	2,4-D
Cottonwood, eastern (*Populus deltoides*)	W	S	AMS; 2,4-D
	W	I	2,4,5-T
	W	R	Amitrole
Cowcockle (*Saponaria vaccaria*)	A	R	Dicamba; silvex; 2,4-D 2,4,5-T
Cowparsnip, hogweed (*Heracleum spondylium*)	P	R	Herbicidal oil
Coyotebrush (*Baccharis pilularis*)	W	S	2,4-D
	W	I	2,4,5-T
Coyotillo (*Karwinskia humboldtiana*)	P	S	Fenuron; silvex; 2,4,5-T
Crabgrass (*Digitaria* spp.)	A	S	AMA, atrazine, berefin, bensulide, bromacil, CDEC,

TABLE 16 (Continued)
Weed Species and Herbicides for Their Control

Weed species	Growth habit	Response to herbicide	Herbicide
Crabgrass (con.)			chlorpropham, DCPA, dichlobenil, diphenamid, DSMA, EPTC, MSMA, naptalam, norea, paraquat, prometryne, TCA, terbacil, terbutol, trifluralin, sesone, simazine
		R	Silvex; 2,4-D; 2,4,5-T
Cranesbill (see geranium, Carolina)			
Crazyweed, Lambert (*Oxytropis lambertii*)	P	I	Silvex; 2,4-D; 2,4,5-T
Creeping-charlie (see ground ivy)			
Creosotebush	W	S	Fenuron
(*Larrea tridentata*)	W	I	Monuron; silvex; 2,4-D; 2,4,5-T; 2,3,6-TBA
Crotolaria, showy (*Crotolaria spectabilis*)	A	I	2,4-D
Croton			
Lindheimer	A	S	2,4-D
(*Croton lindheimeri*)	A	I	Silvex; 2,4,5-T
Texas (*C. texensis*)	A	S	Silvex; 2,4-D; 2,4,5-T
wooly (*C. capitatus*)	A	S	Silvex; 2,4-D; 2,4,5-T
Crowfoot grass (*Dactyloctenium aegyptium*)	A	S	Benefin, diphenamid, terbacil, trifluralin
Cudweed (*Gnaphalium* spp.)	A	S	Dichlobenil
Cupgrass (*Eriochloa* spp.)	A	S	Naptalam
Currants (*Ribes* spp.)	W	S	AMS; 2,4-D; 2,4,5-T
Cutgrass (*Leersia* spp.)	P	S	Amitrole; dalapon
	P	I	Silvex; TCA
Daisy			
English (*Bellis perennis*)	P	I	2,4-D
	P	R	CBM, CBMM
oxeye (*Chrysanthemum leucanthemum*)	P	S	Atrazine; 2,4,5-T
		I	Silvex; 2,4-D
Dallisgrass (*Paspalum dilatatum*)	P	S	AMA, bromacil, dalapon, DSMA; MSMA
	P	I	Diuron, monuron
Dandelion, common (*Taraxacum officinale*)	P	S	Bromacil; dichlobenil; picloram + 2,4-D; silvex;

TABLE 16 (Continued)
Weed Species and Herbicides for Their Control

Weed species	Growth habit	Response to herbicide	Herbicide
Dandelion, common (con.)			sodium chlorate; 2,4-D; 2,4,5-T; 2,3,6-TBA
	P	I	BMM, CBMM
	P	R	Amitrole, DCPA
Dayflower, common (*Commelina communis*)	A	S	2,4-D
Deadnettle, red (*Lamium purpureum*)	A or B	R	Bensulide; EPTC; nitralin; 2,4-D
Deathcamas			
foothill (*Zigadenus paniculatus*)	P	S	2,4-D
grassy (*Z. gramineus*)	P	I	2,4-D
Deervetch, broom (*Lotus scoparius*)	W	S	2,4-D; 2,4,5-T
Desert-baileya (see baileya, desert)			
Devilsclaw (*Proboscidea louisianaica*)	A	S	2,4-D
Dewberry (see blackberry)			
Dichondra (*Dichondra repens*)	P	S	Silvex; 2,4-D; 2,4,5-T
Dock			
(species not designated)	P	S	Picloram + borate; picloram + 2,4-D
broadleaf (*Rumex obtusifolius*)	P	S	Silvex; 2,4-D; 2,4,5-T
curley (*R. crispus*)	P	S	Atrazine; dichlobenil; 2,4-D; 2,4,5-T
		I	MonuronTCA, sodium chlorate
		R	Silvex
fiddleleaf (*R. pulcher*)	P	S	2,4-D
pale (*R. altissimus*)	P	S	Silvex; 2,4-D; 2,4,5-T
veiny (*R. venosus*)	P	I	2,4-D
		R	Diuron, monuron, simazine
Dodder (*Cuscata* spp.)	P	S	Chlorpropham, DCPA, diquat, herbicidal oils
		R	Most other herbicides
Dogbane			
hemp (*Apocynum cannabinium*)	P	S	Atrazine
		I	2,4-D
		R	Amitrole; 2,4,5-T
spreading (*Apocynum androsaemifolium*)	P	S	Bromacil; 2,4,5-T

TABLE 16 (Continued)
Weed Species and Herbicides for Their Control

Weed species	Growth habit	Response to herbicide	Herbicide
Dogfennel (*Eupatorium capillifolium*)	A	S	Bromacil; dicamba; terbacil; silvex; 2,4-D; 2,4,5-T
yellow (see bitterweed or bitter sneezeweed)			
Dog mustard (*Erucastrum gallicam*)	A	S	2,4-D
Dogwood (*Cornus* spp.)	W	S	Dicamba + 2,4-D or 2,4,5-T; fenuron
		I	Silvex; 2,4-D; 2,4,5-T
		R	Amitrole, simazine
flowering (*C. florida*)	W	S	2,4,5-T
Dokewood (see oak, post)			
Ducksalad (*Herteranthera limosa*)	A	S	Silvex; 2,4-D; 2,4,5-T
Duckweed, common (*Lemna minor*)	A	S	Copper sulfate, diquat
	A	R	Herbicidal oils; silvex; 2,4-D; 2,4,5-T
Eelgrass (see wild celery)			
Elder (*Sambucus* spp.)	W	S	AMS; 2,4,5-T
	W	I	2,4-D
	W	R	Amitrole, diuron, fenuron, monuron
Elm (*Ulmus* spp.)	W	S	AMS; dicamba + 2,4-D or 2,4,5-T; monuron; picloram + 2,4-D
	W	I	Silvex; 2,4,5-T
	W	R	Amitrole; fenuron; 2,4-D
winged (*U. alata*)	W	S	Fenuron, picloram
Elodea			
Canada or common (*Egeria canedensis*)	Aq	S	Acrolein*, aromatic solvents*, dichlobenil, diquat, endothall
densleaved (*E. densa*)	Aq	S	Acrolein*, aromatic,solvents*, dichlobenil, diquat, endothall
Florida (*Hydrilla verticulata*)	Aq	S	Acrolein*, aromatic solvents*, diquat + copper sulfate, endothall (amine)*
		I	Copper sulfate, diquat, endothall (K or Na salt)

TABLE 16 (Continued)
Weed Species and Herbicides for Their Control

Weed species	Growth habit	Response to herbicide	Herbicide
Eucalyptus (*Eucalyptus* spp.)	W	S	AMS
Euonymus (*Euonymus fortunei* var. *vegetus*)	W	I	AMS, diuron, dinoseb, simazine, TCA
	W	R	Dalapon
Evening-primrose, common (*Oenothera biennis*)	B	S	Dichlobenil; silvex; 2,4-D, 2,4,5-T
Falseflax (*Camelina* spp.)	A	S	Amitrole; 2,4-D
	A	R	Dicamba
False helebore, western (*Veratrum californicum*)	P	S	Silvex
		I	2,4-D
Fanweed (see pennycress, field)			
Fanwort (*Cabomba caroliniana*)	Aq	S	Silvex; simazine; 2,4-D
	Aq	R	Diquat, endothall
Fennel, common (*Foeniculum vulgare*)	P	R	Herbicidal oils
Fescue (species not designated)	P	S	Atrazine, dichlobenil
Fiddleneck coast (*Amsinckia intermedia*)	A	S	Silvex; 2,4-D; 2,4,5-T
Fieldcress, Austrian (*Rorippa austriaca*)	P	I	2,4-D
Fieldmadder (*Sherardia arvensis*)	A	R	2,4-D
Filaree, redstem (*Erodium cicutarium*)	A or B	S	Atrazine; DCPA; paraquat; 2,4-D
Fir			
balsam (*Abies balsamea*)	W	I	AMS
	W	R	Amitrole; 2,4-D
red (*A. magnifica*)	W	R	2,4-D
white (*A. concolor*)	W	R	2,4-D
Fireweed (*Epilobium angustifolium*)	A	S	Simazine
Fleabane			
annual (*Erigeron annus*)	A	S	Atrazine; silvex; 2,4,5-T
		I	2,4-D
Oregon (*E. speciosus*)	P	I	2,4-D
rough (*E. strigosus*)	A or B	S	Silvex; 2,4-D, 2,4,5-T
Flixweed (*Descurainia sopia*)	A or B	S	2,4-D

TABLE 16 (Continued)
Weed Species and Herbicides for Their Control

Weed species	Growth habit	Response to herbicide	Herbicide
Florida pusley (*Richardia scabra*)	A	S	Benefin; DCPA; EPTC; norea; prometryne; terbacil; trifluralin; simazine; 2,4-D
		I	Chlorpropham
		R	Herbicidal oils
Foolsparsley (*Aethusa cynapium*)	A	R	Herbicidal oils
Four-o'clock, prairie (*Mirabilis nycataginea*)	P	S	2,4-D
	P	R	Erbon
Foxtail (*Setaria* spp.)	A	S	AMA, atrazine, benefin, bromacil, CDEC, chlorpropham, dalapon, DCPA, DSMA, EPTC, MSMA, naptalam, norea, prometryne, sesone, siduron, simazine, TCA, trifluralin
		R	Silvex; terbutol; 2,4-D; 2,4,5-T
bristly (*S. verticillata*)	A	S	Amitrole, dalapon, diuron, monuron, TCA
		R	Silvex; 2,4-D; 2,4,5-T
knotroot (*S. geniculata*)	A	S	Amitrole, dalapon, diuron, monuron, TCA
		R	Silvex; 2,4-D; 2,4,5-T
Frenchweed (see pennycress, field)			
Fumitory (*Fumaria officinales*)	A	R	2,4-D
Galinsoga, hairy (*Galinsoga ciliata*) and smallflower (*G. parviflora*)	A	S	Atrazine; silvex; 2,4-D; 2,4,5-T
	A	R	Chlorpropham, DCPA
Gallberry (*Ilex glabra*)	W	I	2,4,5-T
Garlic, wild (*Allium vineale*)	P	S	Dicamba; methyl bromide; SMDC; 2,3,6-TBA
	P	I	Dalapon; fenac; MH; 2,4-D
	P	R	Amitrole; silvex; 2,4,5-T
Geranium, Carolina (*Geranium carolinianum*)	A or B	S	Atrazine; silvex; 2,4-D, 2,4,5-T
Goatsrue (*Galega officinalis*)	P	I	2,4-D; 2,4,5-T
Goatweed (see croton, Lindheimer)			
Golden-aster, false (*Chrysopsis* spp.)	P	I	BMM
		R	Simazine, TCA

TABLE 16 (Continued)
Weed Species and Herbicides for Their Control

Weed species	Growth habit	Response to herbicide	Herbicide
Goldenchain-tree (*Laburnum anagyroides*)	W	I	Dalapon, TCA
Goldenweed, fleece (*Haplopappus arborescens*)	W	I	2,4-D
Goldenrod (*Solidago* spp.)	P	S	AMS; atrazine; bromacil; picloram + 2,4-D
	P	I	2,4-D
Gooseberries (*Ribes oxyacanthoides* and *R. roezlii*)	W	S	2,4-D
most other *Ribes* spp.	W	S	2,4,5-T
Goosefoot (species not designated)	A	S	Trifluralin; 2,4-D
Jerusalem-oak (*Chenopodium botrys*)		S	2,4-D
nettleleaf (*C. murale*)	A	S	EPTC; 2,4-D; 2,4,5-T
		R	Endothall
oakleaf (*C. glaucum*)	A	S	2,4-D; 2,4,5-T
		I	Silvex
		R	Endothall
perennial (*C. ambrosioides*)	A	S	Silvex; 2,4-D; 2,4,5-T
Goosegrass (*Eleusine indica*)	A	S	Bensulide; CDEC; chlorpropham; DCPA; EPTC; diphenamid; naptalam; norea; prometryne; simazine; trifluralin
	A	I	DSMA, MSMA
		R	Silvex; 2,4-D; 2,4,5-T
Gooseweed (*Sphenoclea zeylanica*)	A	I	2,4-D; 2,4,5-T
	A	R	Silvex
Gorse (*Ulex europaeus*)	W	I	2,4-D; 2,4,5-T
	W	R	Sodium chlorate
Gourd, buffalo (*Cucurbita foetidissima*)	P	S	-do-
	P	R	2,4-D
Goutweed, bishops (*Aegopodium podograria*)	P	R	-do-
Greasewood (*Sarcobatus vermiculatus*)	W	I	2,4-D
Greenbrier, saw (*Smilax bona-nox*)	W	S	AMS
		I–R	Amitrole; monuronTCA; silvex; 2,4-D; 2,4,5-T; 2,3,6-TBA

TABLE 16 (Continued)
Weed Species and Herbicides for Their Control

Weed species	Growth habit	Response to herbicide	Herbicide
Gromwell			
common (*Lithospermum officinale*)	P	R	2,4-D
corn (*L. arvense*)	A	I	2,4-D
Groundcherry			
(species not designated)	W	S	DCPA; diphenamid, naptalam, picloram + borate, prometryne, trifluralin
		R	Benefin
clammy (*Physalis heterophylla*)	W	I	Silvex; 2,4,5-T
and purpleflower (*P. lobata*)	W	R	2,4-D
smooth (*P. subglabrata*)	W	R	Silvex; 2,4-D; 2,4,5-T
wrights (*P. wrightii*)	A	S	-do-
Ground-ivy (*Glechoma hederacea*)	P	S	Monuron, silvex
			2,4-D; 2,4,5-T
Groundsel			
(species not designated)	A & P	S	Dichlobenil, paraquat, terbacil
arrowleaf (*Senecio triangularis*)	P	I	2,4-D; 2,4,5-T
common (*S. vulgaris*)	A	S	Monuron, sodium chlorate
	A	R	Silvex; 2,4-D; 2,4,5-T
cressleaf (*S. glabellus*)	A	S	-do-
Riddell (*S. riddellii*)	P	S	2,4-D
tansy ragwort (see tansy ragwort)			
threadleaf (*S. longilobus*)	P	I	2,4-D
Guava (*Psidium guajava*)	W	S	Fenuron; 2,4,5-T
Gum, black (*Nyssa sylvatica*)	W	S	AMS
	W	I	Fenuron; silvex; 2,4,5-T
	W	R	Amitrole; 2,4-D
Gumweed (*Grindelia squarrosa*)	P	S	2,4-D
Hackberry, western	W	S	AMS: fenuron; 2,4,5-T
(*Celtis occidentalis*)	W	R	Amitrole
Halogeton	A	S	2,3,6-TBA
(*Halogeton glomeratus*)	A	I	2,4-D
		R	Silvex; 2,4,5-T
Hawkbit			
fall (*Leontodon autumnalis*)	P	I	2,4-D
rough (*L. nudicaulis*)	P	I	2,4-D; 2,4,5-T
Hawksbeard, smooth (*Crepis capillaris*)	A or B	R	CBM; CBMM; silvex; 2,4-D; 2,4,5-T

TABLE 16 (Continued)
Weed Species and Herbicides for Their Control

Weed species	Growth habit	Response to herbicide	Herbicide
Hawkweed			
mouse-ear (*Hieracium pilosella*)	P	S	2,4-D
orange (*H. aurantiacum*)	P	I	2,4-D
	P	R	CBMM; 2,4,5-T
yellow (*H. pratense*)	P	I	2,4-D
	P	R	2,4,5-T
Hawthorn (*Crataegus* spp.)	W	I	AMS; fenuron; 2,4,5-T
	W	R	Amitrole; monuron; monuronTCA; silvex; 2,4-D
fleshy (*C. succulenta*)	W	I	2,4-D; 2,4,5-T
Hazel (*Corylus* spp.)	W	I	Fenuron; 2,4-D; 2,4,5-T
		R	Amitrole
Heal-all (*Prunella vulgaris*)	P	S	2,4-D
	P	R	Silvex; 2,4,5-T
Hedgemustard (*Sisymbrium officinale*)	A	S	Silvex; 2,4-D; 2,4,5-T
Heliotrope, wild (*Heliotropium* spp.)	W	I	Erbon
	W	R	Sodium chlorate
Hemlock, eastern (*Tsuga canadensis*)	W	R	Simazine; 2,4-D; 2,4,5-T
Hemp (*Cannabis sativa*)	A	S	2,4-D; 2,4,5-T
Hempnettle (*Galeopsis tetrahit*)	A	S	Amitrole
	A	R	2,4-D
Henbane, black (*Hyoscyamus niger*)	A	R	2,4-D
Henbit (*Lamium amplexicaule*)	A	S	CDEC, dicamba, dichlobenil, norea, terbacil, sesone, silvex
		I	2,4,5-T
		R	Chlorpropham; 2,4-D
Hickory (*Carya* spp.)	W	S	AMS; dicamba + 2,4-D or 2,4,5-T; picloram + 2,4-D
	W	I	Amitrole; fenuron; monuron; silvex; 2,4,5-T
	W	R	2,4-D; 2,3,6-TBA
Hoary cress (*Cardaria draba*)	P	S	Amitrole, atrazine
		I	CBM; diuron; monuron; monuronTCA; silvex;

TABLE 16 (Continued)
Weed Species and Herbicides for Their Control

Weed species	Growth habit	Response to herbicide	Herbicide
Hoary cress (con.)			sodium chlorate; 2,4-D; 2,4,5-T
Hogpeanut, southern (*Amphicarpa bracteata*)	P	S	2,4-D
Hogpotato (*Hoffmanseggia densiflora*)	P P	S R	Fenac; 2,3,6-TBA Silvex; 2,4-D; 2,4,5-T
Honeylocust (*Gleditsia triacanthos*)	W W	I R	AMS; 2,4,5-T 2,4-D
Honeysuckle (*Lonicera* spp.)	W W	S I	AMS; amitrole, fenac; picloram + 2,4-D; silvex; TCA Diuron; dinoseb; simazine 2,4-D; 2,4,5-T
Hophornbeam, eastern (*Ostrya virginiana*)	W W W	S I R	AMS 2,4,5-T Fenuron
Hornwort (see coontail, common)			
Horsebrush, littleleaf (*Tetradymia glabrata*)	W	R	2,4-D; 2,4,5-T
Horsenettle, Carolina (*Solanum carolinense*)	P

TABLE 16 (Continued)
Weed Species and Herbicides for Their Control

Weed species	Growth habit	Response to herbicide	Herbicide
Hydrangea, smooth (*Hydrangea arborescens*)	W	S	2,4-D
Indian mallow (see velvetleaf)			
Indian-rushpea (see hogpotato)			
Indian-tobacco (*Lobelia inflata*)	A	I	2,4-D
Iris, Rocky Mountain (*Iris missouriensis*)	P	I	2,4-D
	P	R	Silvex; 2,4,5-T
Ironwood, western (*Veronia baldwini*)	P	S	Amitrole; 2,4-D; 2,4,5-T
	P	R	Silvex
Ironwood (see hophornbeam)			
Ivy, English (*Hedera helix*)	P	S	2,4,5-T
	P	I	2,4-D
Jerusalem-artichoke (*Helianthus tuberosus*)	P	S	2,4-D; 2,4,5-T
Jimmyweed (*Haplopappus pluriflorus*)	P	I	2,4-D; 2,4,5-T
Jimson weed (*Datura stramonium*)	A	S	Atrazine; naptalam; 2,4-D; 2,4,5-T
		I	Norea
		R	Benefin, DCPA, diphenamid, trifluralin
Johnson grass (established plants) (*Sorghum halepense*)	P	S	Bromacil, BMM, dalapon, DSMA, herbicidal oils, MSMA, sodium chlorate, TCA
		I	CBM, CBMM, erbon, fenac, monuron, monuronTCA
		R	Amitrole; amitrole-T; CDEC; chlorpropham; MH; norea; prometryne; simazine; 2,4-D; 2,4,5-T
Jointvetch, northern (*Aeschynomene virginica*)	A	S	2,4,5-T
		I	Silvex; 2,4-D
Jungle rice (*Echinochloa colonum*)	A	S	Benefin, diphenamid, prometryne, simazine, trifluralin
Juniper (*Juniperus* spp.) (see also redcedar, eastern)	W	S	Amitrole; diuron; fenuron; monuron; 2,3,6-TBA
	W	I	AMS, simazine, picloram

TABLE 16 (Continued)
Weed Species and Herbicides for Their Control

Weed species	Growth habit	Response to herbicide	Herbicide
Juniper			
redcedar, eastern (con.)	W	R	Silvex; 2,4-D; 2,4,5-T
creeping (*J. horizontalis*)	W	S	Simazine
Kidneywort baccharis (see coyotebrush)			
Kikuyugrass (*Pennisetum clandestinum*)	P	S	CBM, erbon
	P	I	Dalapon, sodium chlorate, TCA
	P	R	Amitrole
Kinghead (see ragweed, giant)			
Klamath-weed (see St. John's-wort)			
Knapweed (*Centaurea* spp.)	P	S	Dicamba, picloram, sodium chlorate
black (*C. nigra*), brown (*C. jacea*), spotted (*C. maculosa*)	P	S	Atrazine; dicamba; picloram; sodium chlorate; silvex; 2,4-D
Russian (*C. repens*), and squarrosa (*C. squarrosa*)	P	S	Dicamba; picloram; picloram + borate; picloram + 2,4-D; sodium chlorate
		R	Amitrole; amitrole-T; silvex; simazine; 2,4-D; 2,4,5-T
Knawel, annual (*Scleranthus annus*)	A	S	Chlorpropham; silvex
		R	2,4-D; 2,4,5-T
Knotweed			
Japanese (see smartweed, Japanese)			
(species not designated)	A	S	Benefin; dichlobenil; diphenamid; naptalam; terbacil; trifluralin
prostrate (*Polygonum aviculare*)	A	S	Atrazine, chlorpropham, dicamba, dinoseb, monuron, sodium chlorate
		I	Silvex; 2,4-D; 2,4,5-T
sakhalin (*P. sachalinense*)	P	S	2,4-D
silversheath (*P. argyrocoleon*)	A	I	-do-
Kochia (*Kochia scoparia*)	A	S	Atrazine; silvex; trifluralin; 2,4-D; 2,4,5-T
Kudzu (*Pueraria lobata*)	P	I	Silvex; 2,4-D; 2,4,5-T
		S	Picloram + 2,4-D

TABLE 16 (Continued)
Weed Species and Herbicides for Their Control

Weed species	Growth habit	Response to herbicide	Herbicide
Ladysmantle, field (*Alchemilla arvensis*)	P	R	2,4-D
Ladysthumb (see smartweed, ladysthumb)			
Lambsquarters, common (*Chenopodium album*)	A	S	Atrazine; benefin; bensulide; bromacil; DCPA; dichlobenil; diphenamid; EPTC; naptalam; norea; prometryne; terbacil; trifluralin; sesone; silvex; simazine; 2,4-D; 2,4,5-T
		R	Chlorpropham, endothall
Lantana (*Lantana camara*)	W	S	BMM, CBMM, fenuron
		R	MonuronTCA
Larch (*Larix* spp.)	W	I	2,4-D; 2,4,5-T
Larkspur			
(species not designated)	P	S	Picloram + borate; picloram + 2,4-D
duncecap (*Delphinium occidentale*)	P	I	Silvex; 2,4,5-T
	P	R	2,4-D
little (*D. bicolor*)	P	R	Silvex; 2,4-D; 2,4,5-T
menzies (*D. menziesi*)	P	I	2,4-D; 2,4,5-T
tall (*D. barbeyi*)	P	S	Silvex plus 2,4,5-T
		I	Fenuron, silvex, TCA
		R	Amitrole; 2,4-D; 2,4,5-T
Leatherwood (*Dirca palustris*)	W	S	2,4-D
Leptotaenia, carrotleaf (*Leptotaenia dissecta*)	P	S	2,4,5-T
	P	I	2,4-D
Lettuce			
blue (*Lactuca pulchella*)	P	S	Atrazine
	P	I	Silvex; 2,4-D; 2,4,5-T
prickly (*L. scariola*)	P	S	Atrazine; BMM; simazine; 2,4-D
tall (*L. canadensis*)	P	S	Atrazine
Licorice, wild (*Glycyrrhiza lepidota*)	P	I	CBMM; 2,4-D
Lilac (*Syringa vulgaris*)	W	S	2,4,5-T
Linden (see basswood)			

TABLE 16 (Continued)
Weed Species and Herbicides for Their Control

Weed species	Growth habit	Response to herbicide	Herbicide
Locoweed			
bigbend (*Astragalus earlei*)	A or P	S	2,4-D
Locust, black (*Robinia pseudoacacia*)	W	S	Amitrole; dicamba + 2,4-D or 2,4,5-T; picloram + borate; picloram + 2,4-D; silvex; 2,3,6-TBA; 2,4,5-T
	W	I	AMS: monuron; 2,4-D
Loosestrife			
spiked (*Lythrum salicaria*)	Aq	S	Silvex
	Aq	I	2,4-D
swamp (see swamp loosestrife)			
Lotebush, condalia (*Condalia obtusifolia*)	W	S	2,4-D; 2,4,5-T
Lotus, American (*Nelumbo lutea*)	Aq	S	AMS; dichlobenil; silvex; 2,4-D; 2,4,5-T
	Aq	R	Dalapon
Lupine			
stream (*Lupinus rivularis*)	W	S	2,4-D; 2,4,5-T
silvery (*L. argenteus*)	P	S	Silvex; 2,4,5-T
	P	I	2,4-D
tailcup (*L. caudatus*)	P	S	2,4-D
Madrone, Pacific (*Arbutus menziesii*)	W	I	2,4-D; 2,4,5-T
Magnolia (*Magnolia* spp.)	W	S	2,4,5-T
Maidencane (*Panicum hemitomon*)	Aq	S	Dalapon
	Aq	I	Monuron, TCA
	Aq	R	Amitrole; BMM; 2,3,6-TBA
Mallow			
(species not designated)	A	S	Prometryne
alkali (see sida, alkali)			
common (*Malva neglecta*)	A	R	Silvex; 2,4-D; 2,4,5-T
		I	2,4-D
dwarf (*M. rotundifolia*)	P	R	Dinoseb; herbicidal oils; 2,4-D
Indian (see velvetleaf)			
little (*M. parvifloral*)	A	I	2,4-D
venice (*Hibiscus trionum*)	A	S	2,4-D; 2,4,5-T
		R	Benefin, diphenamid, trifluralin
Mannagrass, water (*Glyceria fluitans*)	Aq	R	Copper sulfate; silvex; sodium chlorate; 2,4-D

TABLE 16 (Continued)
Weed Species and Herbicides for Their Control

Weed species	Growth habit	Response to herbicide	Herbicide
Manzanita (*Arctostaphylos* spp.)	W	I	Silvex; 2,4-D; 2,4,5-T
greenleaf (*A. columbiana*)	W	R	2,4-D; 2,4,5-T
Maple			
(*Acer* spp.)	W	S	AMS; dicamba + 2,4-D or 2,4,5-T; fenac; picloram + borate; picloram + 2,4-D; silvex
	W	I	Diuron; dinoseb; fenuron; 2,4,5-T
	W	R	Amitrole; 2,4-D
Norway (*A. Plantanoides*)	W	I	Dalapon, TCA
Marestail (see horseweed)			
Marigold, corn (*Chrysanthemum segetum*)	A	R	2,4-D
Marshelder (*Iva xanthifolia*)	A	S	Silvex; 2,4-D; 2,4,5-T
Marshmarigold (*Caltha palustrus*)	P	I	2,4-D
Meadowrue			
purple (*Thalictrum dasycarpum*)	P	S	Atrazine
Meadowsweet (see spirea)			
Medic, black (*Medicago lupulina*)	A	S	Silvex
Medusahead (*Taeniatherum asperum*)	A	S	Dalapon, simazine
	A	R	Silvex; 2,4-D; 2,4,5-T
Mercury, annual (*Mercurialis annua*)	A	R	2,4-D; 2,4,5-T
Mescalbean (*Sophora secundiflora*)	W	S	Silvex; 2,4,5-T
Mesquite			
honey (*Prosopis juliflora* var. *glandulosa*)	W	S	Fenuron
	W	I	Silvex; 2,4,5-T
	W	R	Amitrole; 2,3,6-TBA; 2,4-D
velvet (*P. juliflora* var. *velutina*)	W	S	Fenuron
	W	I	Silvex; 2,4,5-T
	W	R	2,4-D
Mexicanweed (*Caperonia castaneafolia*)	A	S	Silvex; 2,4,5-T
	A	I	2,4-D
Milkvetch			
(*Astralagus* spp.)	P	S	Silvex; 2,4-D; 2,4,5-T
narrowleaf (*A. pectinatus*)	P	S	Silvex
		I	2,4-D; 2,4,5-T
twogrooved (*A. bisulcatus*)	P	S	2,4-D
Milkweed			
(species not designated)	P	S	Picloram + borate; picloram + 2,4-D; 2,4-D

TABLE 16 (Continued)
Weed Species and Herbicides for Their Control

Weed species	Growth habit	Response to herbicide	Herbicide
Milkweed (con.)			
bloodflower (*Asclepias curassivica*)	P	S	2,4-D; 2,4,5-T
	P	I	Amitrole
broad-leaved (*A. latifolia*)	P	I	Amitrole; silvex; 2,4-D
common (*Asclepias syriaca*)	P	I	Amitrole; silvex
	P	R	Erbon; herbicidal oils; simazine; 2,4-D; 2,4,5-T
eastern whorled (*A. verticillata*)	P	I–R	Amitrole
	P	R	2,4-D, 2,4,5-T
	P	S–I	Picloram
honeyvine (*Ampelamus albidus*)	P	I	Erbon; 2,3,6-TBA
	P	R	2,4-D
showy (*A. speciosa*)	P	S	Silvex
		I	Amitrole
Mint			
field (*Mentha arvensis*)	P	R	2,4-D
water (*M. aquatica*)	Aq	R	2,4-D
Mockorange (*Philadelphus virginalis*)	W	I	Dalapon, diuron, dinoseb, simazine, TCA
Moneywort (*Lysimachia nummularia*)	P	S	2,4-D
Monolepis (*Monolepis nuttalliana*)	A	R	2,4-D
Morning glory (*Ipomoea* spp.)	A	S	Atrazine; DSMA; norea; prometryne; sesone; silvex; simazine; 2,4-D; 2,4,5-T
		I	Chlorpropham; sodium chlorate
smallflower (*Jacquemontia tamnifolia*)	A	S	Atrazine; DSMA; MSMA; silvex
Mountain-mahogany (*Cercocarpus montanus*)	W	R	2,4,5-T
Mugwort (*Artemisia vulgaris*)	P	I	Monuron; monuronTCA
	P	R	2,4-D; 2,4,5-T
Muhly, wirestem (*Muhlenbergia frondosa*)	P	S	Atrazine
Mulberry (*Morus* spp.)	W	S	Fenuron
	W	I	Silvex
	W	R	Amitrole; 2,4-D; 2,4,5-T
Mulesears (*Wyethia amplexicaulis*)	P	S	Silvex; 2,4-D; 2,4,5-T

TABLE 16 (Continued)
Weed Species and Herbicides for Their Control

Weed species	Growth habit	Response to herbicide	Herbicide
Mullein			
common (*Verbascum thapsus*)	B	S	Silvex
		I	2,4,5-T
		R	2,4-D
moth (*V. blattaria*)	P	I	2,4-D; 2,4,5-T
turkey (*Eremocarpus setigerus*)		S	Bromacil
Muskgrass (see algae, *Chara* spp.)			
Mustard			
(species not designated)	A	S	Naptalam, prometryne
		I	Chlorpropham
black (*Brassica nigra*)	A	S	Atrazine; silvex; 2,4-D; 2,4,5-T
		R	DCPA
haresear (*Coringia orientalis*)	A	S	Chlorpropham; 2,4-D
Indian (*B. juncea*)	A	S	Silvex; 2,4-D; 2,4,5-T
white (*B. hirta*)	A	S	2,4-D
wild (*B. kaber*)	A	S	Dichlobenil; silvex; 2,4-D; 2,4,5-T
		R	DCPA, endothall, paraquat
Naiad (*Najas* spp.)	Aq	S	Acrolein*, aromatic solvent*, diquat, endothall (amine)*
Natalgrass (*Rhynchelytrum repens*)	P	S	Terbacil
		R	BMM, CBMM
Needle-and-thread (*Stipa comata*)	P	R	Silvex; 2,4-D; 2,4,5-T
Needlerush (*Juncus roemerianus*)	Aq	S	Diuron; monuron; silvex; 2,4-D
		I	Dalapon
		R	Erbon
Nettle			
(species not designated)	A	S	Paraquat
burning (*Urtica urens*)	A	S	Trifluralin; 2,4-D
stinging (*U. dioica*)	P	S	Monuron; 2,4-D; sodium chlorate
tall (*U. procera*)	A	S	Monuron; 2,4-D
Niggerhead (*Rudbeckia occidentalis*)	P	S	2,4-D
Nightshade			
(species not designated)	A	S	Terbacil
		R	Benefin, diphenamid, simazine, trifluralin
black or purple (*Solanum nigrum*)	A	S	EPTC, silvex
		I	2,4-D; 2,4,5-T
		R	CBMM

TABLE 16 (Continued)
Weed Species and Herbicides for Their Control

Weed species	Growth habit	Response to herbicide	Herbicide
Nightshade (con.)			
cutleaf (*S. triflorum*)	A	I	2,4-D
hairy (*S. villosum*)	A	S	EPTC
silverleaf (*S. elaeagnifolium*)	P	R	CDEC; fenac; 2,3,6-TBA; 2,4-D; 2,4,5-T
Nimblewill (*Muhlenbergia schreberi*)	P	S	Atrazine
		R	Amitrole; diuron; monuron; monuronTCA; 2,4-D; 2,4,5-T
Nut sedge			
(species not designated)	P	S	Bromacil, DSMA
		R	DCPA, norea
purple (*Cyperus rotundus*)	P	S	Amitrole, EPTC, methyl bromide, MSMA
		I	BMM; 2,4-D
		R	Benefin; CDEC; chlorpropham; CIPC; erbon; fenac; monuron; silvex; simazine; TCA; 2,4,5-T
yellow (*C. esculentus*)	P	S	EPTC, methyl bromide, MSMA, TCA, terbacil
		I	Atrazine; 2,4-D
		R	Benefin; CBMM; CDEC; diphenamid; MH; silvex; simazine; trifluralin; 2,4,5-T
Oatgrass, tall (*Arrhenatherum elatius*)	P	S	Atrazine
Oak			
(species not designated)	W	S	Dicamba + 2,4-D or 2,4,5-T; picloram + 2,4-D
black (*Quercus velutina*)	W	I	2,4,5-T
	W	R	2,4-D
blackjack (*Q. marilandica*)	W	I	Silvex; 2,4,5-T
	W	R	2,4-D
blue (*Q. douglasii*)	W	S	Fenuron
	W	I	Silvex; 2,4,5-T
	W	R	2,4-D; 2,3,6-TBA
canyon live (*Q. chrysolepis*)	W	R	2,4-D; 2,4,5-T
Gambel (*Q. gambelii*)	W	I–R	2,4,5-T
interior live (*Q. wislizenii*)	W	R	Silvex; 2,4-D; 2,4,5-T; 2,3,6-TBA
live (*Q. virginiana*)	W	I	2,4,5-T

TABLE 16 (Continued)
Weed Species and Herbicides for Their Control

Weed species	Growth habit	Response to herbicide	Herbicide
Oak (con.)			
Oregon (*Q. garryana*)	W	I	2,4-D; 2,4,5-T
post (*Q. stellata*)	W	S	AMS; fenuron; silvex; 2,4,5-T
	W	I	2,4-D
	W	R	2,3,6-TBA
red, northern (*Q. rubra*)	W	S	AMS, monuron
	W	I	2,4,5-T
	W	R	Amitrole
scrub, California	W	I	Silvex; 2,4,5-T
(*Q. dumosa*)	W	R	2,4-D
shinnery (*Q. havardii*)	W	S	Silvex; 2,4,5-T
	W	I	2,4-D
	W	R	Amitrole; 2,3,6-TBA
shrub live (*Q. turbinella*)	W	I–R	2,4,5-T
Turkey (*Q. laevis*)	W	S	Diuron, monuron, silvex
	W	I	Fenuron; 2,4-D; 2,4,5-T
	W	R	Amitrole; AMS; 2,4,6-TBA
white (*Q. alba*)	W	S	AMS; monuron; 2,4,5-T
	W	I	Silvex; 2,4-D
	W	R	Amitrole
Oats, wild (*Avena fatua* and *A. ludoviciana*)	A	S	Atrazine, bromacil, chlorpropham, dalapon, diuron, EPTC, monuron, paraquat, prometryne, simazine
		R	DCPA; silvex; 2,4-D; 2,4,5-T
Onion			
tapertip (*Allium acuminatum*)	P	I	2,4-D
wild (*A. Canadense*)	P	S	Dicamba; metham; methyl bromide; 2,3,6-TBA
	P	I	2,4-D
	P	R	Amitrole; dalapon; MH; 2,4,5-T
Orache (*Atriplex patula* var. *hastata*)	A	S	2,4-D; 2,4,5-T
	A	R	Endothall
Orchard grass (*Dactylis glomerata*)	P	S	Atrazine, dichlobenil
Osage orange (*Maclura pomifera*)	W	S	AMS; 2,4,5-T
	W	I	Fenuron, silvex
	W	R	2,4-D
Oxalis (see wood sorrel, yellow)			

TABLE 16 (Continued)
Weed Species and Herbicides for Their Control

Weed species	Growth habit	Response to herbicide	Herbicide
Pagoda tree (*Sophora japonica*)	W	R	Dalapon, TCA
Palmetto, saw (*Serenoa repens*)	W	S–I	Silvex
	W	I	2,4,5-T
	W	R	Monuron
Panicum (*Panicum* spp.)	P	S	Benefin, DCPA
		I	Atrazine, BMM, dalapon, monuron, simazine, TCA
		R	CBMM; 2,3,6-TBA; 2,4-D
fall (*P. dichotomiflorum*)	P	S	DCPA, diphenamid, MSMA, norea, trifluralin
Texas (*P. texanum*)	P	S	DCPA, dichlobenil, trifluralin
Paragrass (*Panicum purpurascens*)	Aq	S	Amitrole-T, dalapon, simazine, monuron
		I	TCA
Parrotfeather (*Myriophyllum brasilense*)	Aq	S	Acrolein*, aromatic solvents*, diquat, endothall (amine)*
		I	Silvex; 2,4-D
Parsnip, wild (*Pastinaca sativa*)	B	S	Atrazine; 2,4-D; 2,4,5-T
Partridgepea (*Cassia fasciculata*)	A	S	Silvex; 2,4-D; 2,4,5-T
Paspalum			
knotgrass (*Paspalam distichum*)	Aq	S	Amitrole-T, dalapon, DSMA
Panama (*P. fimbriatum*)	Aq	S	MSMA
water (*P. fluitans*)	Aq	S	Amitrole-T, dalapon, DSMA
Passion flower, maypop (*Passiflora incarnata*)	P	S	Silvex
	P	I	2,4-D
Pea, wild (*Lathyrus aphaca*)	P	S	2,4-D
Pea-tree (see caragana or pea-tree)			
Pecan (*Carya illinoensis*)	W	S	AMS
	W	R	Fenuron
Pellitory, Florida (*Parietaria floridana*)	A	S	2,4,5-T
	A	R	2,4-D
Pennycress, field (*Thlaspi arvense*)	A	S	Atrazine; diphenamid; silvex; 2,4-D; 2,4,5-T

TABLE 16 (Continued)
Weed Species and Herbicides for Their Control

Weed species	Growth habit	Response to herbicide	Herbicides
Pennywort			
lawn (*Hydrocotyle sibthorpioides*)	P	S	Silvex; 2,4-D; 2,4,5-T
water (*H. umbellata*)	Aq	S	Diquat; 2,4-D
Penstemon, Rydberg	P	I	-do-
(*Penstemon rydbergii*)	P	R	2,4,5-T
Pepperweed or peppergrass (*Lepidium* spp.)	A	S	Dichlobenil, diphenamid
field (*L. campestre*)	A	S	2,4,5-T
	A	I	Silvex
green flower (*L. densiflorum*)	A	S	2,4-D
perennial (*L. latifolium*)	P	I	2,4-D; 2,4,5-T
Virginia (*L. virginicum*)	A	S	Silvex; 2,4-D; 2,4,5-T
yellow flower (*L. perfoliatum*)	A	S	-do-
Persimmon			
common (*Diospyros virginiana*)	W	S	AMS; fenuron; 2,3,6-TBA
	W	I	Amitrole; monuron; silvex; 2,4,5-T
	W	R	2,4-D
Texas (*D. texana*)	W	S	Silvex; monuron; 2,4-D
Pickerelweed (*Pontederia cordata*)	Aq	S	Silvex; 2,4-D; 2,4,5-T
Pigweed (species not designated)	A	S	Atrazine; benefin; diphenamid; DSMA; MSMA; paraquat; picloram + 2,4-D; naptalam; sesone; simazine; terbacil; trifluralin
		I	Chlorpropham
		R	Norea
Palmer (*Amaranthus palmeri*)	A	S	Benefin; CDEC; diphenamid; prometryne; silvex, simazine; trifluralin; 2,4-D; 2,4,5-T
prostrate (*A. graecizans*)	A	S	Atrazine; EPTC; silvex; 2,4-D; 2,4,5-T
redroot (*A. retroflexus*)	A	S	Atrazine; bensulide; CDEC; DCPA; dichlobenil; EPTC; silvex; 2,4-D; 2,4,5-T
smooth (*A. hybridus*)	A	S	Silvex; 2,4-D; 2,4,5-T
spiny (*A. spinosus*)	A	S	CDEC; silvex; 2,4-D; 2,4,5-T
tumble (*A. albus*)	A	S	Atrazine; dicamba; EPTC; silvex; 2,4-D; 2,4,5-T

TABLE 16 (Continued)
Weed Species and Herbicides for Their Control

Weed species	Growth habit	Response to herbicide	Herbicide
Pimpernel, scarlet (*Anagallis arvensis*)	A	I	2,4-D
Pincherry (*Prunus pensylvanica*)	W	S	2,4-D
Pine (species not designated)	W	S	Dicamba + 2,4-D or 2,4,5-T; picloram
jack (*Pinus banksiana*)	W	S	Dalapon, TCA, picloram
	W	R	2,4-D; 2,4,5-T
Jeffrey (*P. jeffreyi*)	W	R	-do-
lodgepole (*P. contorta*)	W	I	2,4,5-T; picloram
	W	R	2,4-D
red (*P. resinosa*)	W	S	Amitrole; picloram
	W	R	2,4-D; 2,4,5-T
white (*P. strobus*)	W	S	Dalapon, picloram, TCA
	W	I	2,3,6-TBA
	W	R	Amitrole; simazine; 2,4-D; 2,4,5-T
Pineappleweed (species not designated)	A	S	Dichlobenil
(*Matricaria matricarioides*)	A	I	2,4-D
		R	Atrazine; dinoseb; herbicidal oils; silvex; 2,4-D; 2,4,5-T
Pinque (see rubberweed, Colorado)			
Plantain (*Plantago* spp.)	A or P	S	Dichlobenil; paraquat; picloram + 2,4-D
blackseed (*Plantago rugelii*)	P	S	Silvex; 2,4-D; 2,4,5-T
bracted (*P. aristata*)	A	S	2,4-D
broadleaf (*P. major*)	P	S	Atrazine; silvex; 2,4-D; 2,4,5-T
buckthorn (*P. lanceolota*)	P	S	-do-
slender (*P. pusilla*)	A	S	2,4-D
woolly (*P. purshii*)	A	S	-do-
Plum			
chickasaw (*Prunus angustifolia*)	W	S	AMS, fenuron
	W	I	2,4,5-T; 2,3,6-TBA
	W	R	Amitrole; silvex; 2,4-D
wild (see cherry)			
Poison hemlock (*Conium maculatum*)	B	S	Silvex; 2,4-D
	B	I	2,4,5-T
	B	R	Herbicidal oils
Poison-ivy (*Rhus radicans*)	W	S	Amitrole; AMS; fenuron; silvex; 2,4,5-T
	W	I	2,4-D

TABLE 16 (Continued)
Weed Species and Herbicides for Their Control

Weed species	Growth habit	Response to herbicide	Herbicide
Poison-oak, Pacific (*Rhus diversiloba*)	W	S	Amitrole; AMS; picloram + 2,4-D; silvex; 2,4,5-T
	W	I	2,4-D
	W	R	MonuronTCA, sodium chlorate
Poison-sumac (*Rhus vernix*)	W	S	Amitrole; AMS: 2,4,5-T
Pokeweed (*Phytolacca americana*)	P	S	Silvex; 2,4,5-T
	P	I	2,4-D
Pondweed (*Potamogeton* spp.)	Aq	S	Acrolein*, aromatic solvents*, diquat, endothall (amine)*
		I	Endothall (dipotassium or disodium)*; silvex; 2,4-D
American (*Potamogeton nodosus*)	Aq	S	Dichlobenil
giant (*P. virginatus*)	Aq	S	-do-
horned (*Zannichellia palustrus*)	Aq	S	Aromatic solvents*, endothall (amine)*, simazine
		I	Copper sulfate; endothall; silvex; 2,4-D
leafy (*P. foliosus*)	Aq	S	Acrolein*, aromatic solvents*, diquat, endothall (amine)*
sago (*P. pectinatus*)	Aq	S	Acrolein*, aromatic solvents*, dichlobenil, diquat, endothall (amine)*
		R	Copper sulfate; 2,4-D
waterthread (*P. diversifolius*)	Aq	S	Dichlobenil
Poolmat, common (see pondweed, horned)			
Poorjoe (*Diodia teres*)	A	S	2,4-D; 2,4,5-T
	A	I	Silvex
Poplar, or popple (*Populus tremuloides*) (see aspen, trembling)			
(species not designated)	W	S	Dicamba + 2,4-D
balsam (*P. balsamifera*)	W	S	2,4-D
Poppy (*Papaver* spp.)	A	R	2,4-D
Roemer (*Roemeria refracta*)	A	S	2,4-D
Povertyweed (*Iva axillaris*)	P	S	Picloram + borate; picloram + 2,4-D; 2,4-D
	P	I	2,3,6-TBA
Prairie grass (see rescue grass)			

TABLE 16 (Continued)
Weed Species and Herbicides for Their Control

Weed species	Growth habit	Response to herbicide	Herbicide
Pricklepoppy, bluestem (*Argemone intermedia*)	A	S	2,4-D
Prickly-ash, common (*Zanthoxylum americanum*)	W W	I R	2,4,5-T 2,4-D
Primrose-willow (*Jussiaea peruviana*)	Aq	S	Diuron; monuron; silvex; 2,4-D; 2,4,5-T
Puncturevine (*Tribulus terrestris*)	A A	S I	Fenac; 2,4-D Bromacil; MSMA; silvex; 2,4,5-T
Purpletop (*Triodia flava*)	P	S	Bromacil
Purslane, common (*Portulaca oleracea*)	A	S	Atrazine; benefin; CDEC; chlorpropham; DCPA: dichlobenil; diphenamid; EPTC; MSMA; naptalam; norea; paraquat; prometryne; sesone; simazine; silvex; terbacil; trifluralin; 2,4,5-T
		I	Dicamba; 2,4-D
		R	BMM, endothall, erbon
Quackgrass (*Agropyron repens*)	P	S	Amitrole-T, atrazine, bromacil, dichlobenil, EPTC, monuron, simazine, sodium chlorate, TCA, terbacil
		I	Amitrole, CBM, CBMM, dalapon, erbon, fenac, MH, monuronTCA
		R	BDM; CDEC; chlorpropham; silvex; terbutol; 2,4-D; 2,4,5-T
Queen's delight (*Stillingia sylvatica*)	P	R	2,4-D
Quickweed (*Galinsoga* spp.)	A	S	Naptalam
Rabbitbrush, rubber (*Chrysothamnus nauseosus*) and Douglas (*C. viscidiflorus*)	W W	I R	2,4-D Silvex; 2,4,5-T
Radish, wild (*Raphanus raphanistrum*)	A A	S R	Silvex; 2,4-D; 2,4,5-T Endothall
Ragweed (*Ambrosia* spp.)	A	S	Bromacil; dichlobenil; MSMA: naptalam;

TABLE 16 (Continued)
Weed Species and Herbicides for Their Control

Weed species	Growth habit	Response to herbicide	Herbicide
Ragweed (con.)			picloram + borate; picloram + 2,4-D; prometryne; simazine; terbacil
		I	Norea
		R	Chlorpropham
blood (*Ambrosia aptera*)	A	S	2,4-D; 2,4,5-T
common (*A. artemisiifolia*)	A	S	Atrazine; BMM; silvex; 2,4-D; 2,4,5-T
		R	Benefin, DCPA, diphenamid, trifluralin
giant (*A. trifida*)	A	S	Atrazine; silvex; 2,4-D; 2,4,5-T
perennial (*A. psilostachya*)	P	S	AMS; silvex; 2,4-D; 2,4,5-T
Ragwort, golden (*Senecio aureus*)	P	I	Diuron; monuron; monuronTCA
Rape, wild (*Rapistrum rugosum*)	A or B	S	2,4-D
Raspberry, wild black or red (see blackberry)			
Rattail fescue (*Festuca myuros*)	A	S	Chlorpropham, simazine
Rattleweed (*Rhinanthus* spp.)	A	S	2,4-D
Redbay (*Persea borbonia*)	W	S	2,4,5-T
	W	R	Silvex; 2,4-D
Redbud (*Cercis canadensis* and *C. occidentalis*)	W	S	AMS, silvex
	W	I	Fenuron
	W	R	2,4-D; 2,4,5-T
Redcedar, eastern (*Juniperus virginiana*)	W	S	Diuron, fenuron, monuron, picloram
		R	AMS; amitrole; 2,3,6-TBA; 2,4-D; 2,4,5-T
Red clover (*Trifolium pratense*)	B	S	Paraquat; 2,4-D; 2,4,5-T
Redmaids, rock purslane (*Calandrinia caulescens*)	P	S	Benefin
Redstem (*Ammannia auriculata*)	A	S	Silvex; 2,4-D; 2,4,5-T
Redtop (*Agrostis* spp.)	A or P	S	Amitrole, bromacil, diuron, methyl bromide, monuron
	A or P	I	Dalapon
	A or P	R	2,4-D; 2,4,5-T

TABLE 16 (Continued)
Weed Species and Herbicides for Their Control

Weed species	Growth habit	Response to herbicide	Herbicide
Redvine (*Brunnichia cirrhosa*)	P	R	Herbicidal oils; silvex; 2,4-D; 2,4,5-T
Redwood (*Sequoia sempervirens*)	W	I	2,4-D
Reed, common (*Phragmites communis*)	Aq	S	Amitrole, Amitrole-T
		I	Monuron
Rescue grass (*Bromus catharticus*)	A or B	S	Monuron
	A or B	R	Sodium chlorate; 2,4-D; 2,4,5-T
Rocket			
London (*Sisymbrium irio*)	A	S	Silvex; 2,4-D; 2,4,5-T
		R	Bromacil
yellow (*Barbarea vulgaris*)		S	Dichlobenil
Rose			
California (*Rosa californica*)	W	I	2,4-D
Cherokee (*R. laevigata*)	W	S	Monuron, silvex
	W	I	2,4-D; 2,4,5-T
Macartney (*R. bracteata*)	W	I	Silvex; 2,4-D; 2,4,5-T
multiflora (*R. multiflora*)	W	S	Monuron; 2,3,6-TBA
	W	I	Silvex; 2,4,5-T
	W	R	Simazine; 2,4-D
prairie (*R. arkansana* var. *suffulta*)	W	S	2,4,5-T
	W	I	2,4-D
	W	R	BMM
sweetbrier (*R. rubiginosa*)	W	S	Picloram + borate; picloram + 2,4-D
Woods (*R. woodsii*)	W	I	2,4,5-T
		R	Silvex; 2,4-D
Rubberweed			
bitter (*Hymenoxys odorata*)	A	S	2,4-D
pingue (*H. richardsoni*)	P	S	-do-
		I	2,4,5-T; 2,3,6-TBA
Rush (*Juncus* spp.)	Aq	S	Amitrole; atrazine; dalapon; diuron; monuron; silvex; sodium chlorate; 2,4-D
slender (*J. tenuis*)	P	S	2,4-D
Russian pigweed (*Axyris amaranthoides*)	A	S	-do-
Russian thistle (*Salsola kali*)	A	S	Atrazine; bromacil; dicamba; fenac; silvex; simazine; trifluralin; 2,4-D; 2,4,5-T

TABLE 16 (Continued)
Weed Species and Herbicides for Their Control

Weed species	Growth habit	Response to herbicide	Herbicide
Ryegrass (*Lolium* spp.)	A or P	S	Benefin, bromacil, diphenamid, dalapon, EPTC, nitralin, simazine
Sage			
meadow (*Salvia pratensis*)	P	I	2,4-D
Sonoma (*S. Sonomensis*)	P	S	2,4-D; 2,4,5-T
white (*S. apiana*)	P	S	-do-
whiteleaf (*S. Leucophylla*)	P	S	2,4-D
Sagebrush			
big (*Artemisia tridentata*)	W	S	2,4-D; 2,4,5-T
	W	I	Silvex
California (*A. californica*)	W	S	2,4-D; 2,4,5-T
fringed (*A. frigida*)	W	I	2,4-D
sand (*A. filifolia*)	W	S	Silvex; 2,4-D; 2,4,5-T
silver (*A. cana*)	W	I	2,4-D
St-Johns-wort			
Klamath weed	P	S	Monuron, sodium chlorate
(*Hypericum perforatum*)	P	R	Herbicidal oils; 2,4-D
spotted (*H. punctatum*)	P	I	Atrazine; simazine; 2,4-D; 2,4,5-T
Salmonberry (*Rubus spectabilis*)	W	S	Amitrole; silvex; 2,4,5-T
	W	R	2,4-D; 2,3,6-TBA
Salsify (*Tragopogon* spp.)	B or P	S	2,4-D
common (*T. porrifolius*)	B or P	S	2,4-D
meadow (*T. pratensis*)	B	S	2,4-D
western (*T. major*)	B	S	2,4-D
Saltbush (see orache)			
Saltcedar (see tamarisk)			
Saltgrass			
(species not designated)	P	S	Bromacil
seashore (*Disticblis spicata*)	P	I	Diuron, erbon, monuron, sodium chlorate
Saltwort, common (see Russian thistle)			
Sandburs (*Cenchrus* spp.)	A	S	Atrazine, benefin, chlorpropham, dalapon, diphenamid, DSMA, EPTC, fortified oils, MSMA, prometryne, TCA, trifluralin
		R	Silvex; 2,4-D; 2,4,5-T

TABLE 16 (Continued)
Weed Species and Herbicides for Their Control

Weed species	Growth habit	Response to herbicide	Herbicide
Sandwort, thymeleaf (*Arenaria serpyllifolia*)	A	S	2,4-D
Saskatoon serviceberry (*Amelanchier alnifolia*)	W	S	-do-
Sassafras (*Sassafras albidum*)	W	S	AMS; dicamba + 2,4-D or 2,4,5-T; fenac; fenuron; monuron; picloram + 2,4-D; 2,3,6-TBA; 2,4-D; 2,4,5-T
		R	Amitrole
Scotch broom (*Cytisus scoparius*)	W	S	2,4-D; 2,4;5-T
Sedge (*Carex* spp.)	P	S	Amitrole; herbicidal oil + dinoseb; 2,4-D (heavy rate)
		I	Atrazine, dalapon, monuron
Sesbania hemp (*Sesbania exalta*)	A	S	Silvex; 2,4,5-T
Shadblow serviceberry (*Amelanchier canadensis*)	W	S	Fenuron; 2,4-D
	W	R	Amitrole
Shepherd's purse (*Capsella bursa-pastoris*)	A	S	Atrazine; bensulide;. dichlobenil; diphenamid; naptalam; paraquat; silvex; simazine; 2,4-D; 2,4,5-T
Sicklepod (*Cassia obtusifolia*)	A	S	DSMA; MSMA; prometryne; 2,4-D
		R	Chlorpropham
Sida, alkali (*Sida hederacea*)	P	S	Fenac; 2,3,6-TBA
		I	Erbon
		R	Sodium chlorate; 2,4-D
prickly (*S. spinosa*)	P	S	Prometryne
Signalgrass (*Brachiaria* spp.)		S	Diuron, DSMA, MSMA, prometryne, trifluralin
Silverberry (*Elaeagnus commutata*)	W	S	2,4-D
Silvergrass (*Miscanthus* spp.)		S	Simazine
Skeletonweed (*Lygodesmia juncea*)	P	S	Atrazine; 2,4-D

TABLE 16 (Continued)
Weed Species and Herbicides for Their Control

Weed species	Growth habit	Response to herbicide	Herbicide
Skunkbush (*Rhus trilobata*)	W	S	2,4-D
	W	I	2,4,5-T
Skunkcabbage (*Symplocarpus foetidus*)	P	I	Silvex
Skunkweed (see croton, Texas)			
Smartweed (species not designated)	A or P	S	Atrazine, dichlobenil, diphenamid, naptalam, prometryne
		I	Norea
		R	DCPA
green (*Polygonum scabrum*)	A	S	Chlorpropham, dicamba
		R	Endothall; silvex; 2,4-D
Japanese (*P. cuspidatum*)	P	S–I	AMS, BMM, chlorpropham, dicamba, erbon, monuron, silvex, TCA
		I	2,4-D; 2,4,5-T
ladysthumb (*P. persicaria*)	A	S	Atrazine; chlorpropham; silvex; 2,3,6-TBA; 2,4,5-T
		R	DCPA
marshpepper (*P. hydropiper*)	Aq	I	Amitrole, diuron, monuron
Pennsylvania (*P. pennsylvanicum*)	A	S–I	Atrazine; chlorpropham; 2,3,6-TBA; 2,4-D; 2,4,5-T
		I	Silvex
		R	BMM
swamp (*P. coccineum*)	A	S	Chlorpropham, diuron, monuron
		I	2,3,6-TBA
		R	Amitrole; 2,4-D
water (*P. amphibium*)	Aq	S	Chlorpropham; 2,4-D
Smilax (*Smilax* spp.)	W	S	AMS
	W	I	Fenuron
	W	R	Amitrole, monuronTCA, silvex
Smutgrass (*Sporobolus poiretii*)	A or P	S	Amitrole
	A or P	R	Silvex; 2,4-D; 2,4,5-T
Snakeroot, white (*Eupatorium rugosum*)	P	I	2,4-D; 2,4,5-T
	P	R	Silvex

TABLE 16 (Continued)
Weed Species and Herbicides for Their Control

Weed species	Growth habit	Response to herbicide	Herbicide
Snakeweed			
broom (*Gutierrezia sarothrae*)	P	I	2,4-D; 2,4,5-T
	P	R	Silvex
threadleaf (see broomweed threadleaf)			
Snapweed, pale (*Impatiens pallida*)	A	S	2,4-D
Sneezeweed, bitter (see bitterweed)			
Snowberry, western (see buckbrush)			
Snowbrush, ceanothus (*Ceanothus velutinus*)	W	S	2,4,5-T
	W	I	2,4-D
	W	R	Amitrole, AMS, silvex
Snow-on-the-mountain (*Euphorbia marginata*)	A	S	2,4,5-T
		I	2,4-D
Soapberry, western (*Sapindus drummondi*)	W	R	Fenuron
Sorrel			
garden	P	S	2,4-D; 2,4,5-T
(*Rumex acetosa*)	P	I	Silvex
heartwing (*R. hastatulus*)	P	S	2,4-D
red (*R. acetosella*)	P	S	Atrazine; chlorpropham; dicamba; diphenamid; 2,3,6-TBA
	P	I	Silvex
	P	R	Amitrole; erbon; 2,4-D
Sourwood (*Oxydendrum arboreum*)	W	S	Dicamba; monuron; 2,4-D
Sowthistle			
(species not designated)	A or P	S	Picloram + 2,4-D
annual (*Sonchus oleraceus*)	A	S	2,4-D; 2,4,5-T
	A	R	CBM; CBMM
perennial (*S. arvensis*)	P	S	Atrazine; dicamba; fenac; simazine; sodium chlorate; 2,3,6-TBA
	P	I	Amitrole; diuron; monuron; monuronTCA: silvex; 2,4-D; 2,4,5-T
	P	R	CBMM
spiny (*S. asper*)	A	S	2,4-D; 2,4,5-T
Spanish needles (*Bidens bipinnata*)	A	S	Silvex; simazine; 2,4-D; 2,4,5-T

TABLE 16 (Continued)
Weed Species and Herbicides for Their Control

Weed species	Growth habit	Response to herbicide	Herbicide
Spatterdock (*Nuphar advena*)	Aq	S	Silvex
	Aq	I	2,4-D
Speedwell (*Veronica* spp.)	P	S	Atrazine, monuron, sodium chlorate
	P	I–R	2,4-D
	P	R	Silvex; 2,4,5-T
purslane (*V. peregrina*)	P	S–R	Silvex; 2,4-D; 2,4,5-T
Spicebush, common (*Lindera benzoin*)	W	S	AMS; dicamba; 2,4-D; 2,4,5-T
	W	R	Amitrole
Spikegrass (see saltgrass, seashore)			
Spikerush (*Eleocharis* spp.)	P	I	Silvex; 2,4-D; 2,4,5-T
dwarf (*E. parvula*)	Aq	I	Simazine; 2,4-D
	Aq	R	Silvex; 2,4,5-T
Spirea (*Spiraea* spp.)	W	S	Diuron; simazine; 2,4,5-T
Sprangletop (*Leptochloa* spp.)	A	S	Trifluralin
Mexican (*L. uninervia*)	A	R	Silvex; 2,4-D; 2,4,5-T
red (*L. filiformis*)	A	R	Prometryne; silvex; 2,4-D; 2,4,5-T
Spruce (*Picea* spp.)	W	S	AMS; picloram + 2,4-D; 2,3,6-TBA
		I	Dalapon, TCA
black (*P. mariana*)	W	R	Amitrole
white (*P. glauca*)	W	R	2,4-D; 2,4,5-T
Spurge			
flowering (*Euphorbia corollata*)	P	S	2,4,5-T
		R	2,4-D
leafy (*E. esula*)	P	S	AMS; atrazine; dichlobenil; erbon; fenac; picloram + borate; picloram + 2,4-D; 2,3,6-TBA
		I	MonuronTCA, silvex
		R	Amitrole-T; simazine; 2,4-D; 2,4,5-T
spotted (*E. maculata*)	A	I	BMM, CBMM, DCPA, silvex
		R	2,4-D; 2,4,5-T
Spurry, corn (*Spergula arvensis*)	A	S	Chlorpropham, dicamba, EPTC
		I	Silvex
		R	2,4-D; 2,4,5-T
Squirreltail (*Sitanion hystrix*)	P	R	2,4-D; 2,4,5-T

TABLE 16 (Continued)
Weed Species and Herbicides for Their Control

Weed species	Growth habit	Response to herbicide	Herbicide
Stargrass (*Aletris* spp.)	P	S	MSMA
Star-of-Bethlehem	P	S	2,3,6-TBA
(*Ornithogalum umbellatum*)	P	I	2,4-D
Star-thistle			
yellow (*Centaurea solstitialis*)	A	I	2,4-D
	A	R	Herbicidal oils
Stickseed, or sticktight, European (*Lappula echinata*)	A	S	2,4-D
Stinkgrass (*Eragrostics cilianensis*)	A	S	Chlorpropham, DCPA, diphenamid, EPTC, naptalam, trifluralin
Stinking-willie (see tansyragwort)			
Stinkweed (see pennycress, field)			
Stonewort (*Chara* spp.)	Aq	S	Copper sulfate
Strawberry, wild (*Fragaria* spp.)	P	S	Attrazine, dicamba
		I	Silvex
		R	2,4-D; 2,4,5-T
Sumac (*Rhus* spp.)	W	S	AMS; fenuron; 2,3,6-TBA; 2,4-D; 2,4,5-T
	W	I	Amitrole
skunkbush (*R. trilobata*)	W	I–R	Silvex; 2,4,5-T
smooth (*R. glabra*)	W	S	2,4-D + 2,4,5-T
staghorn (*R. typhina*)	W	S	Amitrole; 2,4-D + 2,4,5-T
Sumpweed, rough (*Iva ciliata*)	A	S	2,4-D
Sunflower			
common (*Helianthus annus*)	A	S	Atrazine; picloram + 2,4-D; silvex; 2,4-D; 2,4,5-T
		R	Benefin, diphenamid, trifluralin
prairie (*H. petiolaris*)	A	S	2,4-D
Swamp loosestrife (*Decodon verticillatus*)	Aq	S	Silvex
Sweetclover, yellow annual (*Melilotus indica*)	A	S	2,4-D
Sweetfern (*Comptonia peregrina*)	W	I	2,3,6-TBA; 2,4-D

TABLE 16 (Continued)
Weed Species and Herbicides for Their Control

Weed species	Growth habit	Response to herbicide	Herbicide
Sweetgum (*Liquidambar styraciflua*)	W	S	AMS; fenuron; 2,4,5-T
	W	I	Silvex
	W	R	2,4-D
Swinecress (*Coronopus didymus*)	A	S	-do-
Switchgrass (*Panicam virgatum*)	P	S	Atrazine
Sycamore, American (*Platanus occidentalis*)	W	S	AMS; dicamba + 2,4-D or 2,4,5-T; fenuron; 2,4-D; 2,4,5-T
Tamarack (*Larix laricina*)	W	I	2,4-D; 2,4,5-T
Tamarisk, French (*Tamarix gallica*)	W	S	Fenuron; silvex; 2,4-D + 2,4,5-T
		I	2,4,5-T
		R	2,4-D
Tanoak			
(*Lithocarpus densiflora*)	W	R	Silvex; 2,4-D; 2,4,5-T
scrub (*L. densiflora* var. *echinoides*)	W	R	2,4-D; 2,4,5-T
Tansy (*Tanacetum vulgare*)	P	I	-do-
Tansymustard (*Descurainia pinnata*)	A	S	Terbacil; 2,4-D
Tansy-ragwort (*Senecio jacobaea*)	P	S	Sodium chlorate; 2,4-D
		I	Diuron; monuron; silvex; 2,4,5-T
Tanweed (see smartweed, swamp)			
Tarbush (*Flourensia cernua*)	W	S	Fenuron; monuron; 2,4-D
	W	I	Silvex; 2,4,5-T
	W	R	2,3,6-TBA
Tarweed, fiddleneck (see fiddleneck, coast)			
Tarweed, showy (*Madia elegans*)	A	S	Atrazine
Thimbleberry (*Rubus parviflorus*)	W	S	2,4,5-T
		I	2,4-D
Thistle			
(species not designated)	B or P	S	Paraquat; picloram + 2,4-D
bull (see bullthistle)			
Canada (*Cirsium arvense*)	P	S	Amitrole; AMS; atrazine; BDM; CBM; dicamba;

TABLE 16 (Continued)
Weed Species and Herbicides for Their Control

Weed species	Growth habit	Response to herbicide	Herbicide
Thistle			
Canada (con.)			dichlobenil; fenac; picloram + borate; picloram + 2,4-D; sodium chlorate; 2,3,6-TBA
		I	BMM; diuron; monuron; monuronTCA; silvex; 2,4-D; 2,4,5-T
		R	Amitrole, erbon, simazine
pasture (*C. pumilum*)	P	S	Atrazine
wavyleaf (*C. undulatum*)	P	R	2,4-D
yellow	B or P	I	-do-
Thornapple (see hawthorn) (*Crataegus* spp.)			
Timothy (*Phleum pratense*)	P	S	Atrazine; dichlobenil
Toadflax, yellow (*Linaria vulgaris*)	P	S	Diuron; monuron; picloram + borate; picloram + 2,4-D
		R	Amitrole; BMM; monuronTCA; silvex; 2,4-D; 2,4,5-T
Torpedo grass (*Panicum repens*)	P	S	Amitrole
	P	R	MonuronTCA
Tree-of-heaven (*Ailanthus altissima*)	W	S	Silvex; 2,4,5-T
	W	I	AMS; 2,4-D
Trumpetcreeper (*Campsis radicans*)	W	S	AMS; silvex
	W	I	2,4-D; 2,4,5-T
	W	R	Amitrole; norea
Tule (see bulrush)			
Tuliptree (*Liriodendron tulipifera*)	W	S	AMS; 2,4,5-T
	W	R	Amitrole; fenuron
Tumblemustard (*Sisymbrium altissimum*)	A	S	2,4-D; 2,4,5-T
Tumbleweed (see pigweed, tumble)			
Tupelo (see gum, black)			
Umbrella plant, smallflower (*Cyperus difformis*)	A	I	2,4-D
	A	R	Silvex; 2,4,5-T
Vaseygrass (*Paspalum urvillei*)	A or P	S	Bromacil
		I	BMM, CBMM, diuron, monuronTCA
		R	Simazine, TCA

TABLE 16 (Continued)
Weed Species and Herbicides for Their Control

Weed species	Growth habit	Response to herbicide	Herbicide
Velvetleaf (*Abutilon theophrasti*)	A	S	2,4-D; 2,4,5-T
		I	Chlorpropham; norea
		R	Benefin, DCPA
Venus's looking-glass (*Specularia perfoliata*)	A	I	2,4-D
Vervain (*Verbena* spp.)	P	S	-do-
Vetch			
narrowleaf (*Vicia angustifolia*)	A	S	Atrazine; 2,4-D; 2,4,5-T
wild (*Vicia* spp.)	A	S	Silvex; 2,4-D; 2,4,5-T
Viburnum, mapleleaf (*Viburnum acerifolium*)	W	S	2,4-D; 2,4,5-T
Violet (*Viola* spp.)	P	I	Silvex
	P	R	2,4-D
Virginia creeper (*Parthenocissus quinquefolia*)	W	I	2,4-D; 2,4,5-T
Walnut, black (*Juglans nigra*)	W	S	-do-
Waterchestnut (*Trapa notans*)	Aq	S	2,4-D
	Aq	R	Monuron; silvex; 2,3,6-TBA
Watercress (*Nasturtium officinale*)	Aq	S	Monuron; 2,4-D
Water crowfoot (*Ranunculus aquatilis*)	Aq	S	Acrolein*, aromatic solvents*, diquat, endothall (amine)*
Water fern (*Azolla* spp.)	Aq	S	Diquat; 2,4-D and 2,4,5-T in oil-water emulsions
Water hemlock			
spotted (*Cicuta maculuta*)	P	S	Silvex; 2,4-D; 2,4,5-T
western (*C. douglasii*)	P	I	2,4-D
Waterhemp (*Acnida altissima*)	P	S	Atrazine; 2,4-D
Water-hyacinth (*Eichornia crassipes*)	Aq	S	Amitrole-T; diquat; 2,4-D
Waterlettuce (*Pistia stratiotes*)	Aq	S	Diquat
		I	2,4-D esters in oil or oil-water emulsion
Water lily (*Nymphaea* spp.)	Aq	S	Dichlobenil; erbon; silvex; 2,4-D

TABLE 16 (Continued)
Weed Species and Herbicides for Their Control

Weed species	Growth habit	Response to herbicide	Herbicide
Watermilfoil			
broadleaf (*Myriophyllum heterophyllum*)	Aq	S	Acrolein*; diquat; endothall; silvex; simazine; 2,4-D (granular)
Eurasian (*M. spicatum*)	Aq	S	2,4-D (butoxy ethanol ester or granules)
		I	Diquat; endothall (amines)*
northern (*M. exalbescens*)	Aq	S	Dichlobenil; diquat; endothall; 2,4-D (granular)
Waterplantain			
common (*Alisma triviale*)	Aq	S	Silvex; 2,4-D
		R	Copper sulfate
narrowleaf (*A. gramineum*)	Aq	I	Acrolein*, aromatic solvents*, dichlobenil, fenac
		R	Copper sulfate, diquat, endothall
Water primrose (*Jussiaea* spp.)	Aq	S	Acrolein*; dichlobenil; diuron; fenuron; monuron; silvex; 2,4-D; 2,4,5-T
Water purslane (*Ludwigia palustris*)	Aq	S	Monuron
Water shield (*Brasenia schreberi*)	Aq	S	Endothall (all formulations), silvex
		I	2,4-D; 2,4,5-T
Water-stargrass (*Heteranthera dubia*)	Aq	S	Acrolein*, aromatic solvents*, silvex
Water starwort (*Callitriche verna*)	Aq	S	Silvex
		R	Copper sulfate
Waterwillow (*Justica* spp.)	A	I	Diquat
Wedgeleaf (see ceanothus, wedgeleaf)			
White cedar, northern (*Thuja occidentalis*)	W	S	Dalapon, TCA
	W	R	Amitrole, simazine
White clover (*Trifolium repens*)	P	S	Endothall; silvex;
		I	2,4-D; 2,4,5-T
Whitethorn (*Acacia constricta*)	W	S	Fenuron, monuron
	W	I	Silvex; 2,4-D
	W	R	2,3,6-TBA
mountain (*Ceanothus cordulatus*)	W	I	2,4,5-T
		R	Amitrole; 2,4-D

TABLE 16 (Continued)
Weed Species and Herbicides for Their Control

Weed species	Growth habit	Response to herbicide	Herbicide
Wild buckwheat (*Polygonum convoluvulus*)	A	S	Chlorpropham; dicamba; fenac; monuron; sodium chlorate; 2,3,6-TBA
		I	Silvex; 2,4-D
		R	Amitrole
Wild cane (*Sorghum bicolor*)	A	S	EPTC, trifluralin
Wild celery (*Vallisneria* spp.)	Aq	S	Endothall (amine granular)*
		I	Dichlobenil, silvex
Wild cucumber (see burcucumber)			
Wild flax (see coreopsis, plains)			
Wild indigo (*Baptisia tinctoria*)	P	S	2,4,5-T
		I	2,4-D
Wild rye, Canada (*Elymus canadensis*)	P	S	Atrazine
Willow (*Salix* spp.)	W	S	AMS; bromacil; dicamba + 2,4-D; monuron; 2,4-D
		I	Fenuron; silvex; 2,4,5-T
		R	Amitrole, simazine
Willowweed (*Epilobium* spp.)	W	S	Silvex; 2,4-D; 2,4,5-T
Windmill grass, tumble (*Chloris verticillata*)	P	R	Naptalam; 2,4-D
Winter cress (see yellow rocket)			
Witchgrass (*Panicum* spp.)	P	S	MSMA, simazine
(*P. capillare*)	P	S	Atrazine, chlorpropham
Witch-hazel (*Hamamelis* spp.)	W	S	AMS; dicamba + 2,4-D; 2,4,5-T
Witchweed (*Striga lutea*)	A	S	Fenac; silvex; 2,4-D; 2,4,5-T
Wolfberry (see buckbrush, snowberry)			
Woodsorrel, yellow (*Oxalis stricta*)	A or P	S	Atrazine, dichlobenil, MSMA, terbacil, silvex
		R	2,4-D
Wool grass (see bulrush)			
Wormseed mustard (*Erysimum cheiranthoides*)	A	S	Silvex; 2,4-D; 2,4,5-T

TABLE 16 (Continued)
Weed Species and Herbicides for Their Control

Weed species	Growth habit	Response to herbicide	Herbicide
Wormwood			
annual (*Artemesia annua*)	A	S	2,4-D; 2,4,5-T
biennial (*A. biennis*)	B	S	2,4-D
common (*A. absinthium*)	A	S	Amitrole; 2,3,6-TBA; 2,4-D
		R	Erbon
Yankeeweed (*Eupatorium compositifolium*)	P	I	2,4-D; 2,4,5-T
Yarrow			
common (*Achillea folium*)	P	S	Atrazine
	P	I	Silvex; 2,4,5-T
	P	I–R	2,4-D
western (*A. lanulosa*)	P	I	2,4-D; 2,4,5-T
Yaupon (*Ilex vomitoria*)	W	I–R	2,3,6-TBA; 2,4-D; 2,4,5-T
Yellow-rocket (*Barbarea vulgaris*)	B or P	S	2,4-D; 2,4,5-T
	B or P	I	Silvex
Yerbasanta, California (*Eriodictyon californicum*)	W	S	2,4-D; 2,4,5-T
	W	I	Silvex
Yucca (*Yucca* spp.)	W	S	-do-
	W	R	Amitrole, diuron, monuron, monuronTCA
soapweed, small	W	I	Silvex
(*Y. glauca*)	W	R	2,4-D; 2,4,5-T

Section 5. CURRENT HERBICIDES

5.1 ACROLEIN. Acrolein is a highly reactive herbicide that controls submersed aquatic weeds in irrigation and drainage channels. It is extremely toxic to mammals, to fish, and to other aquatic animal life. It is highly volatile and flammable, and its vapor is a powerful irritant to the eyes and respiratory passages. Because of these properties, the chemical must be metered or pumped from a closed container into the water of the channel without contact with air. A formulation of acrolein is available for treatment of irrigation and drainage canals by licensed operators with especially adapted equipment.

5.2 AMA. This is prepared as an aqueous solution containing 8-percent octyl ammonium methylarsonate and 8-percent dodecyl ammonium methylarsonate. Total arsenic in water-soluble form is 4.1 percent. It is compatible with 2,4-D and silvex. In addition to crabgrass, sedge and seedlings of barnyard grass, dallisgrass, and foxtail can be controlled with AMA.

5.3 AMITROLE. Amitrole is formulated as a water-soluble powder for applying in solution. The commercial product is sold in two concentrations: 50-percent and 90-percent amino triazole. It is not hazardous to handle, is not acutely toxic to mammals, and, at normal rates of application, is not harmful to fish. If herbicides having less toxic tendencies will obtain the necessary control they shall be used in lieu of amitrole.

Amitrole can be used for the control of herbaceous weeds, woody plants, and aquatic weeds either alone or in combination with other herbicides. It is safer than 2,4-D, 2,4,5-T, or silvex where drift would be injurious to nearby plants.

Alone, it is adapted for land where long residuals are not required, where quick topkills are needed, and where spot treatment of weeds that have survived or escaped treatment with a soil sterilant is desirable.

Combined with residual-type herbicides, it makes a mixture that not only quickly kills plant growth above ground but also prevents weed growth for one or more seasons and acts more effectively than amitrole alone against deep-rooted perennial weeds. A mixture with dalapon often increases effectiveness against grasses. In combination with simazine, monuron, diuron, or dalapon it can be used in storage yards and parking lots, on railroad beds and ballast, under pipelines, under guide rails and surrounding signposts on highways, on public utility rights-of-way, around buildings and tank farms, along ditchbanks and fence rows, around radio antenna installations and airstrip runway lights, on crushed-rock blankets, and in similar areas where any plant growth is undesirable.

Amitrole is too specific to be a general brush killer. It is especially effective on white ash, black locust, poison-ivy, poison-oak, poison sumac, and staghorn sumac. It has been promising on some conifers. It is readily translocated, so it can be applied to the leaves; but it is not absorbed through the bark, so it can be used to kill vine growth on trees without injury.

Amitrole is more expensive than 2,4-D for the control of cattails and bulrushes, but it is safer to use near crops sensitive to 2,4-D.

5.4 AMITROLE-SIMAZINE. In this mixture, the simazine is added to provide residual toxicity after the quick knockdown of vegetation by the amitrole. This mixture is more effective than amitrole alone for pole yards, parking areas, gravel shoulders and center strips on highways, lumberyards, around buildings, transmission towers, guardrails, bridges, and on similar areas. It does not corrode spray equipment, is nonflammable and odorless, and does not stain.

Weeds resistant to both amitrole and simazine are resistant to the mixture.

5.5 AMITROLE-T. This is a liquid formulation containing 2 pounds of 3-amino-1,2,4-triazole per gallon. The ammonium thiocyanate increases the sensitivity of grasses to amino triazole so that effective control results from lower rates than from amitrole alone. It is more effective than amitrole on quack grass, reed canary grass, and water-hyacinth.

5.6 AMS. AMS is a granular material that is very soluble in water and breaks down rapidly in moist soil. It is nonflammable, nonvolatile, and strongly toxic to plants. No special handling precautions are necessary. It is sold in a formulation containing 95-percent ammonium sulfamate in a crystal form and as a solution containing 5.3 pounds of 95-percent ammonium sulfamate per gallon.

AMS is commonly substituted for the phenoxy compounds in areas where crops sensitive to these chemicals are grown. It is a contact, nonselective herbicide effective over a wide range of conditions and species. It is especially effective on poison-ivy, poison-oak, and poison-sumac. AMS in the crystal form or in concentrated solutions, is successfully used for stump applications. It is corrosive to metals, especially brass and copper. Stainless steel, aluminum, and bronze are resistant. Spray equipment must be protected, but corrosion of fences, guy wires, and telephone wires is negligible.

It is not effective against eastern redcedar, snowbrush, and Turkey oak.

5.7 AROMATIC SOLVENTS. These products are also called solvent naphthas or petroleum naphthas. They include a variety of petroleum and coal distillates that can be used in heavy concentrations for aquatic-weed control. Kerosene—especially as sold in the eastern United States—mineral spirits, tractor distillate, low-grade diesel oil, and similar aliphatic materials do not control submersed weeds. Most effective products are those with a flash point above 80° F., distillation between 278° and

420° F., and an aromatic content of at least 85 percent. These solvents are highly flammable and irritating to the skin and eyes or when fumes are inhaled. Livestock tend to avoid drinking treated water. Vegetation is not harmed when irrigated with treated water.

Aromatic solvents are deadly to fish. They are used in irrigation and drainage ditches, especially in short ditches (6 to 8 miles or less) with even sides and bottoms and with flows of 1 to 70 c.f.s. Acrolein is more practical in longer ditches. The solvents are often mixed with emulsifiers to form a stable emulsion in the water.

5.8 ATRAZINE. Atrazine is formulated as an 80-percent water-dispersible powder and a 4-percent granular product. It is more soluble than simazine, so that it is more effective in dry areas. Weeds better controlled with atrazine than simazine are: horsetail, Indian hemp, prickley lettuce, yellow nutsedge, rush, sedge, and Canada thistle.

Atrazine may be applied preplant, preemergence, or post-emergence, but before the weed seedlings are more than 1-1/2 inches high. It is absorbed through both roots and foliage, although foliar absorption is slight in most plants under field conditions. The herbicide can be washed off plant foliage by rain. It is slightly more toxic to mammals than simazine and remains toxic in the soil for a slightly shorter time.

In low rainfall areas west of the Rocky Mountains, application may be made in the fall, winter, or early spring. Best results are obtained when atrazine is applied before or shortly after weeds emerge.

5.9 BDM. This is a proprietary mixture containing 55-percent disodium tetraborate pentahydrate, 35.5-percent disodium tetraborate decahydrate, and 7.5-percent 2,4-dichlorophenoxy-acetic acid. It is applied dry. BDM is nonpoisonous when used as directed, and is noncorrosive and nonflammable.

The mixture is designed to kill deep-rooted, perennial, broadleaf weeds, but is not recommended for controlling grasses. It results in quicker topkills than borates alone. In semiarid regions, residual toxicity lasts 1 to 2 years at rates of 12-1/2 to 14-1/2 pounds per 1,000 square feet. It is resistant to attack and decomposition by soil organisms, but it is leached below the root zone in soil when exposed to heavy rains.

5.10 BENEFIN. Benefin is a preemergence herbicide which must be watered into the soil. It may be used on established turf grasses, and controls many grasses and broadleaf weeds, such as crabgrass, foxtail, barnyard grass, pigweed, chickweed, and purslane. It is slightly volatile, but in the temperate zone may give control of weeds for 4 to 5 months.

Benefin is a yellow-orange crystalline solid with no appreciable odor. It comes as an emulsifiable concentrate containing 1-1/2 pounds of active ingredients per gallon, and may be dissolved in water.

It is nonflammable, noncorrosive, nonhazardous to mammals and birds, but the toxicity to fish is under study. There is no apparent skin toxicity, or danger through inhalation. The concentrate may irritate the skin and eyes.

5.11 BENSULIDE. This chemical may be obtained in both liquid and granular forms, and it is used for the control of grass and broadleaf weeds in ornamentals, turf, and dichondra lawns.

It should be used before the germination of weed seeds, and may be applied to lawns before planting, at planting, or on established dichondra lawns. The herbicide must be watered into the soil after application, and it provides long residual control of the weeds for which it is registered. Care should be exercised if reseeding with grass is planned after lawn treatment.

5.12 BMM. This is a proprietary mixture containing 63.2-percent disodium tetraborate decahydrate, and 4.0-percent monuron. The B_2O_3 equivalent of the boron compounds in this mixture is 41.4 percent. Both constituents are only slightly toxic to mammals. The formulation is a granular product that is nonflammable and noncorrosive. The boron compounds are effective on broadleaf plants, and monuron is an effective grasskiller. It is slow in action and is resistant to breakdown by soil microorganisms.

5.13 BORATE-BROMACIL-CHLORATE. This compound is a proprietary mixture of 40-percent sodium chlorate, 55-percent sodium metaborate, and 1.6-percent bromacile; and is also available in a formulation containing 4 percent bromacil. It comes in a granular form and is used for railroads and industrial sites to kill weeds and grasses where lasting residual effect is desired. The herbicide should be broadcast and works best when plants are small. Since the killing action is primarily through the roots of the plants, moisture is required after application. It should not be used on or near turf, valuable trees, or other plants or in areas into which their roots may extend.

Avoid contact with skin, eyes, or clothing, and do not breath the dust, as it may cause irritation.

5.14 BROMACIL. This chemical may be obtained as an 80-percent wettable powder, a 50-percent water soluble powder, and a 10-percent pelleted form. All are odorless, nonflammable, and noncorrosive.

Bromacil is used on noncropland areas for the control of a wide range of grass and broadleaf weeds. It may be applied before or during active growth; and to be effective, must be carried into the root zone by moisture. The effects may be slow to appear. At the lower rates it will kill annual weeds; at the higher rates, perennial weeds; and at a very high rate, Johnson grass. The pellets are effective on willow and cottonwood. The powder should not be allowed to drift to sensitive plants, and it should not be used on lawns, walks, driveways, or tennis courts.

Caution should be used to prevent irritation to eyes, nose, throat, and skin.

5.15 CACODYLIC ACID. This is a colorless, crystalline solid. It is a contact herbicide that will defoliate or dessicate a wide variety of plant species. Phytotoxic properties are quickly inactivated on contact with the soil. It can be used for the control of undesirable hardwoods, lawn renovation, and general weed control in non-crop areas such as around buildings, near perennial ornamentals, and along fence rows. The herbicide also can spot-control noxious weeds.

It is nonflammable, mildly corrosive, and may be slightly irritating to the skin. Cacodylic acid is an arsenic containing compound and should not be used where non-arsenical compounds will be equally effective.

5.16 CALCIUM CYANAMIDE. This is a nonacidforming source of organic nitrogen derived from calcium cyanamide and small amounts of related compounds. Properly applied, and with adequate moisture, it kills seeds of most grasses and broadleaf weeds while converting from plant-toxic to nontoxic nitrogen fertilizer. It helps establish new lawns.

The seed bed should be worked into a smooth, level surface and irrigated if not already moist. The chemical is spread on the surface in two directions to get uniform coverage. It is then raked into the top inch of the soil, watered, and kept moist for three weeks. It must not be applied under the drip line of trees, and care should be taken to keep it from washing under the trees. At the end of the three-week period, grass seed may be planted. The chemical does not control well-established perennial weeds.

Care should be taken to avoid contact with skin and eyes, as the herbicide may cause irritation. The vapors should not be inhaled nor should alcoholic beverages be ingested for approximately 24 hours following the use of the herbicide.

5.17 CBM. This proprietary mixture contains 73-percent disodium octaborate and 25-percent sodium chlorate, with a B_2O_3 equivalent of 49 percent. It may be applied dry or as a spray, and is completely soluble in water. Its oral toxicity is low. CBM is noncorrosive to ferrous metals, and the borate acts as a fire deterrent.

This mixture combines the rapid contact action of chlorates with the more persistent toxicity of the borates. The residual toxicity may last 3 to 5 years at rates of 25 to 30 pounds per 1,000 square feet in semiarid regions, but it varies with soil type and rainfall. In spray form, the mixture acts as a contact herbicide, killing topgrowth, and is also absorbed by plant roots.

5.18 CBMM. This compound is a proprietary mixture of 40-percent sodium chlorate, 54-percent sodium metaborate, and 2.4-percent monuron. It is formulated as a powder for both dry and wet application, and as a granular product.

The sodium chlorate and boron compounds are effective against deep-rooted, perennial broad-leaved weeds; and monuron is effective against grasses. The mixture is a long-lasting soil sterilant that is nonpoisonous to mammals. The borate in the mixture is a fire retardant, but some precautions are necessary to avoid a fire hazard.

5.19 CDEC. CDEC is used as a preemergence treatment for the control of a number of grasses and broadleaf weeds, such as barynard grass, crabgrass, foxtail, annual bluegrass, pigweed, henbit, chickweed, careless weed, and purslane. It is safe to use in plantings of gladiolus and iris, and in nursery stock such as 1 to 2 year old shrubs of hydrangea, euonymus, potentilla, spirea, azalea, juniper, yew, and privet.

The herbicide is sold as a liquid that is amber in color and oily. It also comes in a granular form. It is relatively nonflammable, noncorrosive, and may be cleaned from equipment with soap and water. It is moderately toxic to man, so that all reasonable precautions should be taken when it is being used.

5.20 CHLORATE-CHLORIDE (see paragraph 5.58). The herbicidal properties of this mixture are similar to those of sodium chlorate, since the chlorate is the active ingredient. The chloride is added to reduce the fire hazard of the chlorates. Although the fire hazard of the mixture is less than that of sodium chlorate alone, dry accumulations on clothing, wood, or other organic matter may be flammable. Observe the same precautions outlined for sodium chlorate. Rates are based on the amount of chlorate in the mixture. It may be used dry or as a spray.

5.21 CHLORPROPHAM. Chlorpropham is available in a 20-percent granular form, and as a 47-percent concentrate. It acts as a highly selective preemergence and early postemergence herbicide, controlling annual grass and broadleaf weeds. When applied during the fall and winter, it controls some perennial weeds, but the chemical must be moved by water into the upper soil layers. It should be used on established turf only, as grass seedlings are very susceptible. It may also be used on gladioli before growth starts, and on woody ornamental stock.

This herbicide is a low-melting solid, honey-colored, with little odor. It has a high flash point and is noncorrosive. The toxicity to wildlife and fish, if any, is low. There is no skin toxicity.

5.22 COPPER SULFATE. Copper sulfate, often called blue vitriol or bluestone, is the most commonly used herbicide for controlling algae in ponds, lakes, and streams. It is formulated as a 98- to 99-percent salt that is soluble in water. It is corrosive to metals. Large quantities taken into the body may be fatal, and small quantities taken continuously may be injurious. It is toxic to many species of fish at concentrations above 1 p.p.m., which is very close to rates required for aquatic weed control. Toxicity depends on the species of fish, the hardness of the water, and other factors that influence the amount in solution. Concentrations in excess of 5 ppm will affect the taste of water to the extent that it may be undrinkable.

5.23 DALAPON. Dalapon is formulated as the sodium salt of dichloropropionic acid. It is a water-soluble powder applied in solution for a foliage spray. A typical commercial product contains 85 percent of the salt or 74 percent of the acid equivalent. The acute oral toxicity is low. It is not absorbed through unbroken skin. Undiluted, it may cause skin irritation after prolonged contact, but spray concentrations are not irritating. The powder or concentrated solutions can cause painful irritation of the eyes.

Dalapon is used principally to control grasses, but it is also effective against cattails; jack and white pine; rushes; and white-cedar. It is a growth-regulator type of herbicide that is translocated from leaves to roots and rhizomes of perennial grasses. It is more effective in foliar applications than TCA, but it is also absorbed by the roots. For general weed control, it is mixed with a broadleaf weedkiller such as 2,4-D, amitrole, or silvex. Dalapon disappears from the soil most rapidly in warm and humid regions. It persists longer in dry, cool soils where microbial activity is low.

Most broad-leaved weeds are tolerant to resistant.

5.24 DALAPON-SILVEX. An emulsifiable formulation containing 4 pounds dalapon plus one-half pound silvex per gallon is available commercially. The diethylene glycol ester of dalapon and the propylene glycol butyl ether esters (low volatile) of silvex are used. The mixture is noncorrosive and nonpoisonous, but it may cause skin irritation.

It is nonselective and translocated. It is not so dependent on rain as those herbicides that are absorbed by plant roots. It is most effective when plants are growing rapidly. Re-treatment or spot treatments are usually necessary for seasonal control, since it does not have a long residual toxicity in the soil. Drift is a hazard to plants nearby.

5.25 DCPA. This compound is usually called Dacthal on the label. It is formulated as an odorless water-dispersible powder containing 75 percent active ingredient. It is applied preemergence to control crabgrass, some other annual grasses, and certain broad-leaved weeds in established turf. DCPA is not corrosive. It is nonirritating, and is compatible with 2,4-D, chlordane, and the dinitros.

Since DCPA affects seeds, it prevents the germination of turf grass seeds if they are sown soon after the soil has been treated.

5.26 DICAMBA. Dicamba is usually sold in a water solution containing 4 pounds acid equivalent per gallon, but may also be obtained in granular form. Often it is sold as a mixture with 2,4-D. Used as a preemergence treatment, it will control both annual grass and broadleaf weeds. Foliar and soil applications control phenoxy-tolerant annual and perennial broadleaf weeds and brush species. It is effective on several broadleaf weeds such as red sorrel, prostrate knotweed, checkweed, clovers, and wild buckwheat. Dicamba is registered for use on turf and noncropland, and is

readily absorbed from the soil by roots of ornamental shrubs and trees. This chemical is very injurious to ornamental and shade trees. Do not apply where roots of shade trees or ornamental shrubs are growing. No more than 1/4 lb./A. should be used near such plantings. The herbicide may be applied by ground or aerial spray, or as granules—by basal application—and pre- or postemergence depending on the specific need.

For tree and brush control, a mixture of dicamba and 2,4-D, or 2,4, 5-T is effective on noncropland. The mixture should contain 1-1/4 pounds active ingredients of dicamba plus 2-1/2 pounds 2,4-D or 2,4, 5-T, amine or low volatile ester, in 100 gallons of water. This is then applied at the rate of 200 to 300 gallons per acre, to the trees and brush. Such a mixture will control a number of broadleaf weeds if it is applied when the weeds are small.

5.27 DICHLOBENIL. Dichlobenil—a nonselective herbicide that controls both annual and perennial grass, and broadleaf weeds—is absorbed by the seeds and epidermis of the shoots. It is a powerful inhibitor of germination and of actively dividing meristems, and acts primarily on growing points and root tips. The chemical is useful for aquatic weed control, ornamental bermuda grass, ornamental plants and trees, and shelterbelts. It should not be used if the air temperature is expected to go above 70° F. within a week. It is long lasting, and seeding or transplanting in treated soil should be delayed for 24 months after treatment.

The chemical is a white crystalline solid with an aromatic odor, and comes as a wettable powder or in granular form. It is nonflammable, and essentially noncorrosive; but care should be taken to keep it away from the eyes and skin.

5.28 DINOSEB. This is a contact herbicide used alone and to fortify oils. It is a yellow dye that will stain skin, hair, and clothing. Dinoseb is highly poisonous if swallowed, if absorbed through the skin, or if appreciable amounts of spray mist are inhaled. It should be kept away from heat and open flame.

The chemical is nonselective and may be used as a pre- or postemergence spray on seedlings. However, it requires a large amount of water, and its effectiveness varies widely with the air temperature—it should not be used if a temperature of 85° F. is expected within 24 hours. Use on perennial grasses and coarse annual grasses is not economically feasible. Repeated applications are required for control in areas of long seasons and high rainfall.

5.29 DIPHENAMID. This chemical is a white or off-white crystalline solid with no appreciable odor. It is recommended as a preemergence herbicide for use on dichondra and woody ornamentals (evergreens, trees, and flowering shrubs). At recommended rates, it is effective in controlling most annual grass weeds and broadleaf weeds such as pigweed, lambsquarters, smartweed, purslane, Florida pusley, common chickweed, carpetweed and knotweed. It will also kill cereals. Ordinarily, it is sprayed on the soil surface, and full season weed control may be expected at normal rates. Under low rainfall conditions, it is highly persistant in the soil.

5.30 DIQUAT. A nonvolatile and nonflammable contact herbicide, diquat is used for aquatic-weed control as well as on noncropland. Its acute oral toxicity to rats is high.

Concentrated solutions, containing 35.32 diquat, dibromide, must be handled with care and should not be kept in contact with metals. Dilute solutions are relatively safe to handle and are compatible with 2,4-D, substituted ureas, uracil, dalapon, and the s-triazines. The herbicide is rapidly and completely inactivated by contact with the soil. Rates used for aquatic weed control are not toxic to fish. Water treated with Diquat should not be used for drinking, swimming or fishing for a period of 14 days.

5.31 DIURON. Diuron is less soluble in water than monuron. It is formulated as a water-dispersible powder containing 80 percent active ingredient. There is also a liquid suspension, containing 2.8 pounds per gallon active ingredient.

The effects of diuron appear slowly on all weeds. Diuron is more effective than monuron where rainfall is over 25 inches a year, especially in sandy soils. It is not recommended for areas of low rainfall, particularly to control deep-rooted plants. Larger amounts of diuron than monuron are absorbed by all soils; consequently, it is more persistent.

5.32 DSMA. This herbicide is absorbed primarily by foliage and translocates very rapidly, causing a gradual chlorosis of leaves 2 to 4 days after application. The major use is as a selective herbicide for the postemergence control of dallisgrass, foxtails, sandburs, and other grassy weeds in turf. It should not be used on St. Augustine turf.

In noncrop areas it will control Johnson grass, nut sedge, watergrass, sandburs, foxtail, cocklebur, and other weeds.

DSMA comes as a white crystalline solid that contains 63 percent disodium methylarsonate, is nonflammable and mildly corrosive. Skin toxicity is negligible.

5.33 ENDOTHALL. Endothall consists of three isomers, of which the exo-cis isomer shows the greatest biological activity. Its acute oral toxicity to mammals is high; therefore, endothall must be handled with care. It is sold commercially as a 20-percent water solution containing 2 pounds per gallon of the disodium salt, and as a water solution containing 6.3 percent of the disodium salt plus ammonium sulfate. Endothall is noncorrosive and nonflammable.

Endothall is selective; but, combined with 2,4-D it provides control of many grasses and broadleaf weeds. It breaks down rapidly in the soil so that residual toxicity is short, especially in the humid areas. It is absorbed by plant roots, but it may be translocated in some plants.

Both liquid and granular formulations are used for aquatic-weed control. A typical liquid formulation is a water solution containing 19.2 percent disodium endothall. A granular formulation contains 5 percent disodium endothall on an inert

clay carrier. Potassium and amine formulations are also used for aquatic weeds. In most cases, the concentration of amine salt needed to kill the weeds is fatal to fish (amine salt is toxic to fish at 0.3 p.p.m. or higher). Concentrations of 10 p.p.m. of sodium and potassium salts are harmless to fish. Either may be fatal if swallowed, and both are irritating to skin, eyes, nose, and throat.

Both formulations are contact herbicides effective on burreed, coontail, horned pondweed, watermilfoil, and pondweeds (Potamogeton spp.). In northern areas, Pithophora, Cladophora, and Spirogyra algae appear susceptible at the 2 to 5 p.p.m. rate. Because of endothall's short residual life, treated areas that have conditions favorable for algae development may be subject to regrowth within the season. At rates of 1 to 2 p.p.m. of the sodium or potassium salt, there is a wide margin of safety for fish.

5.34 EPTC. EPTC is a selective herbicide for the control of some grass seedlings, and all annual grasses growing from seeds. A number of broadleaf weeds are controlled if application is made when conditions are favorable for germination. It may be used in ornamental plantings. EPTC should be mechanically incorporated into the soil to a depth of 2 to 4 inches immediately after application. If the soil is very dry, it may be incorporated by overhead irrigation. Where flood irrigation is used, EPTC may be metered into the running water.

The chemical comes both as a granular form and as an emulsifiable liquid. The liquid form may be used on field margins, ditch banks, fence rows, under asphalt pavement, and under flowers and nursery stock in cans. The granular form is safer to use in ornamentals.

EPTC is a light yellow-colored liquid with an amine odor. It has a fire point of 240° F., and is non-corrosive.

5.35 ERBON. Erbon combines the properties of 2,4,5-T and dalapon in a single compound. A typical commercial product is an emulsifiable formulation containing 4 pounds technical erbon per gallon. Erbon is moderately toxic to man and livestock. There is little hazard of poisoning in ordinary handling, but it may cause skin and eye irritation.

Erbon is translocated, has the properties of a contact herbicide, and persists in the soil long enough to kill weed seedlings that germinate after treatment. It is effective against both grasses and nongrasses. Hence, it is used to eliminate hand mowing around guide rails, guideposts, signposts, and bridges on highways, and to control vegetation on tank farms. Erbon is also used in lumber yards, railroad yards, and pulp-piling yards; along fences and athletic tracts, and in similar areas.

5.36 FENAC. Fenac consists of several isomers, of which the 2,3,6 isomer is the most toxic to plants. It is considered the active ingredient. Fenac is formulated as a liquid containing 1 1/2 pounds, acid equivalent, per gallon (the active ingredient is the sodium salt), and as a 10-percent granular product. The acute oral toxicity for rats is moderate, and fenac is nonirritating if handled with ordinary precautions.

Fenac causes growth-regulator type responses in plants, but drift hazards are less than with 2,4-D. Effects on plants are slow to appear, especially on deep-rooted perennials. Fenac is persistent in the soil, but conditions favoring microbial activity hasten its breakdown.

5.37 FENURON. Fenuron is more soluble in water than monuron or diuron, but still only small amounts can be dissolved (0.02 lb. per gal. water). It is formulated as a 25-percent pelleted product. Fenuron is inactivated more rapidly than monuron or diuron, and is adapted as a soil sterilant only for dry areas. It is used chiefly to control undesirable brush and trees.

5.38 HERBICIDAL OILS (INCLUDING STODDART SOLVENT). These compounds are used as vegetation topkillers, as solvents in the formulation of herbicides, and as carriers for herbicidal chemicals. Oils that kill by contact should not be used as solvents or carriers of translocated herbicides, since a quick kill of the conducting tissue prevents translocation of the chemical.

Oils vary widely in their composition, value for herbicides, and flammability. Generally, the toxicity to plants is greater with increased content of aromatics. Aside from composition, the value for herbicides is influenced by some physical properties. If the boiling point is low, the oil may evaporate too rapidly; if too high, it does not penetrate plant tissues. The viscosity, or flowing quality, should permit use in cool weather. Specific gravity is important in aquatic-weed control. The flammability is indicated by the flash point; the lower the temperature at which an oil-vapor air-mixture ignites, the greater the danger of explosion. A weed oil that meets the following specifications is satisfactory for nonselective use.

Aromatics	Minimum 50 percent
Boiling range	302° to 527° F.
API gravity	20° to 30°
Flash point	Minimum 180° F.

For convenience in handling during cold weather, the oil should have a maximum pour point of -10° F. Oils below API 27° are heavy and do not pour well in cold weather. However, if oils are too light—above API 38°—they do not have the persistent action needed for chronic poisoning. There are five general classes of oils.

1) Medium-to-heavy, viscous, aromatic oils for general weed control: diesel oils, burner oils, low-grade oils, and oil extracts. They are safe to use and non-corrosive. Diesel oil is available commercially as diesel fuel oil. It varies in aromatic content depending on degree of refinement. Usually it is an effective contact herbicide. Low-grade oils are available only from local refineries in some oil-producing regions; limited amounts of oil extracts are available.

2) Light oils not toxic to all plants and used for selective weed control: stove oil, kerosene distillate, Stoddard solvent, and mineral spirits. They are low in aromatic content.

3) Special oils resulting from the manufacture of gasoline and formulated especially for weed control. Many oils of this type are now available, but they are also low in aromatic content.

4) Fortified oils, whose herbicidal properties have been increased by the addition of pentachlorophenol, dinitrocresol, dinitrobutylphenol, or octachlorocyclohexanone.

5) Emulsifiable oils; oil solutions containing a surfactant capable of causing emulsification upon mixing with water. The oils, in general, are moderately toxic to animals, but kerosene types are highly toxic.

Oil sprays wet leaf surfaces and penetrate waxy leaf surfaces more effectively than water sprays, are less easily washed off the plant, and evaporate more slowly under high temperatures. The effect of oils on perennials is temporary. Oils are used for a quick kill of top growth—a chemical substitute for mowing. They penetrate the leaves of nongrass plants, but kill grasses by creeping down the stem to the crowns and roots. Repeated treatments are necessary where seasons are long and rainfall is high. The cost depends on distance from source of supply. If relatively nontoxic, large volumes are necessary, especially for oil-tolerant species; aerial applications are impractical. Some of the disadvantages of oils used alone can be overcome by fortifying them with phenol compounds or using them in conjunction with soil sterilants. The necessary volume can be reduced, the toxicity to tolerant weeds can be increased, a wider range of oils can be used, and the initial kill can be hastened—but, the cost is raised.

Fortified oil sprays in low volume are effective on small weeds. When plants, especially grasses, are tall enough to protect their crowns, larger spray volumes are required. Emulsions provide larger volume but they do not increase toxicity to plants. The oil content can be varied—10 percent for easy-to-kill species, and up to 25 percent for hard-to-kill species. Frequently, a fortified oil emulsion is more economical than a straight oil emulsion. Oils used as solvents or carriers may or may not be toxic to plants.

The fortified oil emulsions are well suited for killing all vegetation on roadsides, ditchbanks, and similar places, and for spot treatment of shallow-rooted perennials. Staining that may result from oils carrying the dinitros, when used on sidewalks and driveways, is objectionable. Weed oils are preferred for such use and for oil-tolerant weeds.

As a class, oils are insoluble in water; when mixed with water in the presence of a surfactant, they form an emulsion. The common emulsion has oil dispersed in water; an invert emulsion is the reverse—water is dispersed in the oil. The fortifying chemical is dissolved in either the water or the oil, or both.

5.39 METHAM. This compound decomposes in moist soil and becomes toxic to insects and plants. It is readily soluble in water. A typical commercial formulation contains 4 pounds per gallon. It is toxic to mammals, and irritating to eyes and

mucous membranes. Alcoholic beverages should not be ingested for 12-24 hours following exposure to this herbicide.

Metham kills germinating seeds of both grasses and nongrasses, and controls nematodes, soil fungi and insects. It can be sprayed on the soil surface and sealed in with water without a cover. Its residual toxicity disappears in about 2 weeks. It is used for preplanting treatment of seedbeds, potting soil, and areas for ornamentals and nursery stock, orchards, vineyards, and turf.

5.40 METHYL BROMIDE. Methyl bromide is a poisonous, colorless, liquified gas that is slightly soluble in water. Although it is generally considered nonflammable and nonexplosive, some mixtures with air can be exploded by a spark. Both the liquid and gas are poisonous, and the effects of exposure are cumulative. Contact with skin causes severe burns. For soil applications, it is formulated as a solution in an inert solvent. Usually it is mixed with a volatile substance whose odor, or its irritating or lachrymose properties, is a warning of the presence of methyl bromide.

This herbicide controls weeds, plant diseases, and insects in the soil. It is effective on nut grass (a weedy sedge) and perennial grasses, but seeds of white clover are resistant. It is used on soils contaminated with seeds, rhizomes, tubers, and other vegetative plant parts before seeding turf areas or setting out trees and shrubs. It is also used for renovating tees, greens, and fairways on golf courses. It makes reworking of old turf areas unnecessary. A cover is necessary to confine the vapor. Follow precautions in its use.

5.41 METHYL BROMIDE PLUS CHLOROPICRIN. This is a poisonous preplant soil fumigant used to control grass and broadleaf weeds in plant beds, and in nurseries of floral crops, turf, and woody perennials used as ornamentals. It may be applied any time of the year when soil temperature is above 45° F. at the 5 inch depth. The fumigant should be injected into the soil, about 5 or 8 inches deep, and the area blanketed with an airtight cover within 20 minutes. If the soil temperature is above 60° F., the cover should remain for at least 2 days; below that temperature, for 3 to 4 days. Crops may be seeded 2 to 3 days after the cover is removed. For transplants, aerate the soil 7 to 10 days before planting.

The herbicide comes in pressurized cylinders and should be handled with care, since the material is poisonous. After use, application equipment should be cleaned with diesel fuel or kerosene.

Do not breathe the vapor, and keep it away from the skin, eyes, and clothing. If contact is made, remove clothes and shoes, and wash the skin with soap and plenty of water. Flush the eyes with water, and get medical attention. Keep children and pets away from plots that are being treated.

5.42 METHYL ISOTHIOCYANATE PLUS CHLORINATED C_3 HYDROCARBONS. This is a mixture containing 80 percent hydrocarbons and 20% methyl isothiocyanate. It is a soil fumigant that controls a large number of weeds, but is dangerous to handle, and

is fatal if inhaled, swallowed, or absorbed through the skin. It will also irritate the eyes, nose, and throat.

The soil should be cultivated one week before treatment, and the top 6 inches kept moist. Inject the chemical into the soil to a depth of 6 to 8 inches; then cover the treated area with a tarpaulin to ensure good results. If the temperature of the air is above 60° F., the cover should stay on for 4 days. However, it should not be used if the soil temperature at the 3 inch level is over 90° F.

After the cover is removed, the soil should be cultivated once a week until all odor is gone. No planting should be done as long as some chemical odor can be detected. It is possible that the amount of ammonium nitrogen in the soil may be raised to a dangerous level. Be sure to keep the chemical away from lawns or desirable plants.

The chemical is very corrosive, and tools should be flushed with kerosene.

5.43 MH. This herbicide is used to reduce mowing expense, since it retards the growth of some grasses. It is formulated as a sodium salt (a water-soluble powder containing 40 percent MH equivalent) and a diethanolamine salt (a water-soluble liquid) containing 3 pounds per gallon of active ingredient. Both formulations are only slightly toxic to man and animals.

5.44 MONURON. Monuron is formulated as a water-dispersible powder containing 80 percent active ingredient. It is also formulated as a granular material.

The effects of monuron are slow to appear on all weeds. Monuron is more effective in light, sandy soils than in heavy types at equivalent rates, and is more activ in mineral soils than those high in organic-matter content. It is much more soluble in water than diuron, so it is better adapted to areas of less than 25 inches of rainfall a year, except along irrigation and drainage ditches. It is also preferred to diuron for soils containing considerable amounts of clay, especially bentonite, or of organic matter. At high rates, it leaches readily from sandy soils and moves downward twice as fast as diuron in both clay and sandy soils. It is somewhat more effective on grasses than on nongrasses and gives better control than sodium chlorate. Heavy rainfall and standing or running water, conditions favoring microbial activity such as warm soils of high organic-matter content and moisture, and soil cultivation shorten its persistence in the soil. Sterility of the soil may last 1 to 3 years; this depends on rates applied, soil type, and rainfall.

5.45 MONURONTCA. This compound combines monuron, which is less soluble than fenuron, with TCA. Commercially, it is formulated as an 11- and 22-percent granular product and an oil-soluble liquid concentrate containing 3 pounds active ingredient per gallon. It is irritating to skin and eyes. The liquid formulation is used for foliage spray.

The period of soil sterilization depends on soil and rainfall. Both constituents (monuron and TCA) are readily leached from porous soil in areas of high rainfall, so

the herbicide is not effective on loose railroad ballast and on sandy soils in the southeastern states.

5.46 MSMA. MSMA is used principally as a selective herbicide for the postemergence control of dallisgrass and some other grass weeds in turf. It has been used for the control of Johnson grass, nut sedge, water grass, sandbur, foxtail, cocklebur, and other weeds. It should not be used on St. Augustine lawns.

This herbicide may be used on noncropland, along fence rows, rights-of-way, and storage yards. MSMA is a white crystalline solid, that is nonflammable and mildly corrosive. It comes as a premixed liquid concentrate of MSMA and a special surfactant, and gives good results on hard to kill weeds.

This chemical is very similar to DSMA.

5.47 NAPTALAM. Liquid Naptalam is a selective preemergence herbicide for the control of many annual broadleaf weeds and grasses in established woody ornamental nursery stock, and in turf. Effective weed control from 3 to 8 weeks is usually obtained with normal rates of application.

It is nonflammable and slightly corrosive; equipment may be cleaned with water.

5.48 NOREA. With preemergence treatments, norea controls a wide range of grass and broadleaf weeds. If soil applications are used, the chemical is tolerated by many woody and herbaceous ornamentals. It may remain in the soil for as long as 5 months.

This chemical is a white, crystalline solid with negligible odor. It is nonflammable, noncorrosive, and the spray equipment may be cleaned with water. It is sold as a wettable powder with 76 percent active ingredients. Norea has slight dermal toxicity.

5.49 PARAQUAT. Paraquat is a foliage spray with rapid absorption, thus it is not affected by rain. Also, action on the plant is very rapid, since wilting may start within 30 minutes. Use of an appropriate surfactant is essential. It will control young grass and broadleaf weeds, and will kill the tops of some perennial grasses, including Kentucky bluegrass. It may be used to kill small weeds a day or two before seeding grass, and may be used in nurseries and under shade trees. It is also used to kill weeds in noncrop areas, along fence lines, railroads, and tank areas. There is some evidence that it may be used on aquatic weeds such as alligator weed and southern water grass.

The pure salt is a white, crystalline solid, while the technical formulations are dark red solutions, with a faint ammonia odor. The chemical is completely soluble in water, is nonflammable, and virtually noncorrosive.

Paraquat has a high oral toxicity, and care should be used to avoid contact with skin, eyes, and nose. It is toxic to wildlife, so birds and other wildlife may be harmed

in treated areas. Drift to valuable plants should be avoided. It is inactivated upon contact with the soil.

5.50 PCP. This compound is a contact herbicide used alone and to fortify oils. It is used for topkills of vegetation, but it is considerably less effective than the dinitros over a wide range of plants, and is more difficult to handle. Effectiveness on weeds can be increased by adding ammonium sulfate, aluminum sulfate, or sodium bisulfate. The oil formulation is destructive to rubber.

PCP is highly poisonous if swallowed, if absorbed by the skin, or if appreciable amounts of spray mist are inhaled. Since both the powder and spray mist are very irritating to the nose and throat and cause violent sneezing, and since swallowing would induce immediate vomiting, absorption through the skin is the most likely way for PCP to enter the body. The powder and water solutions are irritating to the skin, but the chemical is readily absorbed.

5.51 PICLORAM. Picloram is a white powder that has a chlorine-like odor. The potassium salt is water soluble. Some forms have a low flash point, but the pellets are nonflammable. Spray equipment should be cleaned with water and ammonia. The oral toxicity is low, but it is mildly irritating to the skin and eyes, so all precautions should be taken. Picloram is recommended for control of woody plants and most perennial broadleaf plants in noncropland areas. With few exceptions (bromus spp., for instance) grasses are resistant, so broadleaf weed control in grass crops is feasible. This chemical is not registered for use on any food or feed crops. Since most broadleaf crops, including kudzu are extremely sensitive, applications should be made so as to avoid drift. Liquid formulations can be applied, under good growing conditions, up to 3 weeks before frost. Granular applications are more successful in the spring or early summer on some species, while fall applications have been more effective on species forming a rosette in autumn. The chemical is rapidly absorbed by both tops and roots, and translocates up and down in the plant, tending to accumulate in the new growth. It persists in soils for more than a year and is leached moderately.

Picloram is sold as a mixture with other herbicides. Mixtures of picloram (1 lb./gal.) plus 2,4-D (2 lb./gal.) and picloram (0.5 lb./gal.) plus 2,4-D (2 lb./gal.) are on the market. Another is a granular formulation of picloram (2.3%) plus borate (95.7%). These mixtures are widely used on woody plants and perennial weeds on noncropland. At such times, drift should be watched very closely. Also, great care should be used to keep picloram out of irrigation water and away from fields containing broadleaf crops. Therefore, establish buffer zones between treatment areas and streams, irrigation ditches, crops and valuable vegetation.

5.52 PROMETONE. Prometone is a nonselective pre-and post-emergence herbicide that controls most annual and perennial broadleaf and grass weeds on noncropland. The application of sprays or granules can be made either before or after weed emergence. Since most of the activity is through the roots, adequate rainfall is needed to move the chemical into the root zone. Water, diesel fuel, or weed oil are the usual carriers.

The chemical is absorbed through both foliage and roots, and is translocated from roots and stems acropetally.

This chemical is white and crystalline. It is nonflammable and noncorrosive; spray equipment may be cleaned with water.

5.53 PROMETRYNE. Prometryne is a selective herbicide that may be used for the control of broadleaf weeds and grasses growing in ornamentals, as well as in other crops. Application may be made preemergence or after the weeds are up. When applied before the weeds are up, it enters plants through the roots. To insure proper placement of the chemical, the seed beds must be well prepared. When applied to emerged weeds as a directed spray, it provides foliar knockdown of existing weeds and/or residual control of later germinating weeds. The chemical will remain in the soil from 1 to 3 months. When applied to foliage, it seems to penetrate rapidly, minimizing removal from the foliage by rain.

The chemical comes in a white, crystalline form, and is nonflammable and noncorrosive. It has a very low toxicity for fish and wild life.

5.54 SESONE. Sesone is a selective herbicide that will kill seedlings of both annual grass and broadleaf weeds. It should be applied after cultivation and before the weed seeds sprout. It will prevent sprouting of seeds for 4 to 6 weeks, so applications should be repeated monthly.

Sesone may be used in evergreens, shrubs, trees, and flowers.

Caution should be used to avoid contact with the chemical as it may cause eye irritation. The chemical is a stable nonvolatile white crystalline solid with a slight odor. It is nonflammable and noncorrosive.

5.55 SIDURON. Siduron is used for the selective control of germinating annual weed grasses, such as crabgrass, foxtail, and barnyard grass, in newly-seeded or established plantings of bluegrass, bentgrass, fescue, redtop, smooth brome, perennial ryegrass, and orchard grass. It should not be used on bermuda grass lawns, nor on golf greens. It may be applied to bare soil as a final operation following spring seeding, or to new fall seedings or established turf in the spring, just before expected emergence of annual weed grasses. Rain or irrigation should occur within 3 days after treatment.

The oral toxicity is very low. It is a white, crystalline solid that is odorless. Protect eyes, nose, throat, and skin to avoid irritation. It is sold as a wettable powder containing 50 percent active ingredients and in granular formulations of lower concentrations.

5.56 SILVEX. Silvex is an organic acid that is formulated as a low-volatile ester, a liquid potassium salt, and a granular product.

When emulsified with water or an oil-water carrier, the ester formulation is used as a selective translocated foliar spray to control many broad-leaved weeds and some woody plants. Commercial products are formulated of mixed propylene glycol butyl ether esters, a butoxyethanol ester, or an iso-octyl ester of silvex to contain 4 pounds, acid equivalent, per gallon. Undiluted, the esters are very painful to the eyes and irritating to the skin; but in diluted spray mixtures, they are only mildly irritating. In acute oral toxicity, they are similar to esters of 2,4-D and 2,4,5-T.

Ester formulations of silvex are used in much the same way as esters of 2,4,5-T, except that (1) they are safer where drift onto cotton is a hazard, (2) they are more effective as a foliage spray on maple, redbud, Cherokee rose, saltcedar, and trumpet-creeper, (3) they are not so effective for basal-bark and cut-surface applications, and (4) they are more effective on mouse-ear chick-weed, henbit, and yucca. At high temperatures and high altitudes, silvex may volatilize and cause injury to adjacent vegetation.

The liquid salt formulation is a solution of the potassium salt of silvex containing 6 pounds, acid equivalent, per gallon. It is used to control aquatic weeds. This formulation is less toxic than the ester formulations to fish, except brown trout. It does not injure land plants growing adjacent to treated areas. It is similar to 2,4-D in its effect on many species of submersed aquatic weeds, and is more effective on some. Handling precautions are similar to those for the ester formulations.

The granular product contains 20-percent acid equivalent. It is used to control the same aquatic weeds as the liquid salt. Handling precautions are similar to those for the liquid salt and esters except that there is more danger of inhaling dust and less danger of skin irritation. Toxicity to fish is the same as for the liquid salt.

Aquatic weeds susceptible to silvex are: arrow-head, coontail, fanwort, parrot-feather, pickerel-weed, primrose-willow, spatterdock, water-hyacinth, water lilies, watermilfoil, waterplantain, watershield, water-stargrass, and water-starwort.

5.57 SIMAZINE. Simazine is practically insoluble in water. It is formulated as an 80-percent water-dispersible powder and as a 4-percent granular product. Both formulations are used for the nonselective control of vegetation on areas where any plant growth is undesirable. The granular product is also effective against rooted aquatic plants such as coontail, fanwort, horned pondweed, and watermilfoil.

Simazine is adsorbed by soil colloids. High cation-exchange capacity, high organic-matter content and, to a less extent, high clay content of soils reduce its toxicity to plants. It is probably also deactivated by soil micro-organisms. Simazine has little or no contact action on foliage, so there is no drift hazard. It cannot penetrate an unbroken leaf cuticle and is absorbed only through the roots. Simazine is ineffective until water carries it to the root zone, and its action is slow. It is easily removed from equipment by washing. It forms a suspension in water that requires agitation to keep the chemical from separating out.

5.58 SODIUM CHLORATE. When unmixed with other chemicals, sodium chlorate is readily soluble in water. Because it strongly supports fire, it is frequently mixed with soluble borates or calcium chloride to reduce this hazard. The solubility of the mixtures is considerably less than sodium chlorate alone. Sodium chlorate is relatively nontoxic to man and animals unless consumed in large quantities. Because of its salty taste, sodium chlorate may increase the palatability of poisonous plants that would not otherwise be eaten by livestock.

Sodium chlorate is an inexpensive, long-lasting soil sterilant in dry areas and a relatively temporary one in humid areas. The rate of decomposition is hastened by high temperatures and adequate moisture, which are favorable to microbial action; it is readily leached in coarse-textured soils; it is not readily absorbed by plants in soils high in nitrates or salts. It is absorbed by active roots in moist soil but not by dormant roots in dry soil. With adequate rain, chlorate is distributed throughout the soil profile, but in dry soils the chlorate is confined to the upper layers. Nitrates, which prevent absorption of the chlorate by plant roots, are also accumulated in these layers. The effectiveness of sodium chlorate is also reduced by a high organic-matter content and a high pH of the soil. It is generally applied to the soil, but it can be used as a foliar spray for a quick topkill. It may be translocated when applied as a foilar spray. It is highly toxic to many plants, but there are resistant species.

The most important disadvantage of sodium chlorate is its flammability when in contact with organic matter, sulfur, sulfides, phosphorus, powdered metals, strong acids, or ammonium salts. When stored in paper or cloth sacks or when dry on clothing or vegetation after spraying, it may be ignited by friction, a spark, or even the heat of the sun. It burns so rapidly that the operator can be injured severely or buildings destroyed before the fire can be extinguished. In spite of the danger of handling sodium chlorate, large quantities are used safely by following the proper precautions.

5.59 TCA. This compound is readily soluble in water. It is formulated as the sodium salt containing 94 percent active ingredient and 82.8 percent acid equivalent, and as a liquid containing 5 pounds per gallon, acid equivalent. In the liquid form it tends to decompose and liberate chloroform. In warm storage, it may expand to the extent of damaging the containers. Solutions of 10 percent or more may burn skin and eyes unless washed off immediately. There is no practical hazard to livestock from eating or contacting sprayed foliage. In concentrations of 10 percent or more, TCA corrodes low-quality steel, galvanized iron, zinc, aluminum, and brass.

TCA is used to control grasses. It is not so effective as dalapon in foliar applications, but it is somewhat more persistent in the soil. It disappears through leaching and microbial activity. It is so soluble that it is quickly leached by heavy rainfall and in well-drained soils. It is also adsorbed in clay and organic soils and disappears more slowly from muck than sandy soils. For mixed populations of broad-leaved and grass plants, some broad-leaved weedkiller is added. The effectiveness of TCA is greatly increased by tillage; rates of application can be reduced from one-half to two-thirds.

Most of the broad-leaved weeds, including bitterweed, false golden-aster, purple nut grass, pagoda tree, and vaseygrass, are resistant.

5.60 TERBACIL. Terbacil is used to control many annual and some perennial weeds. It is best to work the soil first, remove top growth if necessary, and then apply before growth starts. It must reach the root zone; this will require either rainfall or irrigation. The effects are slow to appear, but may last for several months.

Terbacil should not be used on walks, driveways, or tennis courts. It may irritate eyes, nose, throat, and skin, so necessary precautions are needed. It is a white, crystalline solid with no odor, and is sold as a wettable powder having 80 percent active ingredients.

5.61 TERBUTOL. This chemical may be purchased as a wettable powder containing 80 percent active ingredients, and readily disperses in water. Terbutol is used as a preemergence herbicide on established lawns and turf to control crabgrass. It should not be used on newly seeded turf. A large number of lawn grasses are resistant to terbutol if it is used according to directions.

5.62 TRIFLURALIN. Trifluralin will control germinating grass seeds and many broadleaf weeds. Crabgrass, foxtail, and barnyard grass are highly sensitive. It is safe to use in gladiolus and ornamentals, as well as in fruit and nut crops. It is used as a preemergence treatment, and must be immediately incorporated in the soil with equipment that breaks up clods and mixes soil thoroughly.

It is an orange crystalline solid, with no appreciable odor, and is noncorrosive and nonflammable. Trifluralin is not a hazard to mammals and birds, but it is toxic to fish if placed in the water.

5.63 2,3,6-TBA. This compound is a mixture of isomers; 2,3,6 predominates with lower amounts of 2,3,4; 2,3,5; 2,4,5; 2,4,6; and 3,4,5. It is formulated as the dimethylamine salt of trichlorobenzoic acid, containing 2 pounds per gallon acid equivalent. It is nonvolatile, noncorrosive, and nonflammable. It is a mild skin irritant. It is compatible with 2,4-D amine, dalapon, diuron, and monuron.

This compound is more effective than 2,4-D, 2,4,5-T, or silvex on field bindweed; bur-franseria; white cockle; halogeton; Russian knapweed; leafy spurge; and Canada thistle.

5.64 2,4-D. 2,4-D is formulated as water-soluble sodium, ammonium, or amine salts and volatile or low-volatile esters. Sodium salts and esters are also available as dusts. A new formulation is the diamine salt. It is an oil-soluble amine that has the weedkilling properties of an ester and the nonvolatile features of amine salts. It is formulated in a concentrate containing 2 pounds, acid equivalent, per gallon.

2,4-D is used for the control of herbaceous broad-leaved weeds. To avoid fish kill, amine formulations are preferred for control of aquatic weeds. It can be applied

at extremely low concentrations compared with the inorganic herbicides, such as borates and chlorates. It is absorbed through leaves and is readily translocated in the plant, but it is also absorbed by plant roots. It is commonly used as a selective herbicide rather than a soil sterilant. Its effect, when applied to the soil, is temporary except under very dry conditions or cool weather. It is more effective on broad-leaved weeds when applied as a foliar spray than on grasses, although in some areas it has killed grass seedlings when applied in large amounts to the soil.

2,4-D is used on many perennial broad-leaved weeds, since it is translocated to the roots and underground storage organs. It is carried with the sugars as they move out of the leaves. It is, therefore, most effective on warm sunny days when photosynthesis is active. It is a very useful herbicide to kill annual nongrass weeds that frequently reinfest an area treated with a soil sterilant after it has leached below the surface layer. It is also an inexpensive and convenient chemical to kill certain weeds that are tolerant to a soil sterilant. On roadsides and similar areas where grasses are desirable for erosion control and in turf, 2,4-D can be used selectively to kill broad-leaved plants in sod. 2,4-D is also effective on certain broad-leaved aquatic plants. High volatile esters will not be used for improved grounds or other grounds where drift or volitalization of herbicide could damage desirable crops in adjacent areas.

2,4-D is also used for the control of woody plants. The salt formulations are practically nonvolatile but, with the possible exception of the diamine salt, are less effective than the esters on hard-to-kill species. The low-volatile esters are equally as effective as the volatile esters and in some instances are better. Some woody species are tolerant to 2,4-D but susceptible to 2,4,5-T and vice versa. For use on mixed populations, the two herbicides are combined in a formulation sold as "brush killers." These brush killers contain one-third to one-half 2,4,5-T and two-thirds to one-half 2,4-D. Brush killers are also effective on poison-ivy, poison-oak, and poison-sumac.

The esters are used extensively in oil for basal-bark, stump, and cut-surface applications. Diesel oil, kerosene, and water are used as carriers. They are used in the fall and winter on deciduous trees when there are few active leaves present or in the summer to increase penetration of leaves, bud scales, and bark. Water is commonly used as the carrier with ester in emulsion for foliage sprays. Only small amounts of oil can be used for this latter purpose (up to 10 gallons per acre), since oil kills leaf tissue and hence prevents movement of the chemical to the roots.

5.65 2,4,5-T. 2,4,5-T is generally used in the ester formulation although there are sodium and triethanolamine salts. There is also a new diamine formulation containing 2 pounds, acid equivalent, per gallon; 2,4-D and 2,4,5-T are also combined in a formulation called "brush killer." The diamine salt brush killer contains 1 pound, acid equivalent, of 2,4-D plus 1 pound, acid equivalent, of 2,4,5-T; other brush killers contain the esters in combinations of one-third to one-half 2,4,5-T to two-thirds to one-half 2,4-D.

2,4,5-T can be used for the selective control of broad-leaved weeds in pastures and rangelands, but it is used principally for the control of woody plants. Like 2,4-D, it is a growth-regulator type of herbicide that can injure nearby broad-leaved plants through drift. Handling precautions are the same as for 2,4-D. The salt formulations are practically nonvolatile but, with the possible exception of the diamine salt, are less effective than the esters on woody plants. The low-volatile esters are equally as effective as the volatile esters and in some instances are better. High volatile esters will not be used for improved grounds or other grounds where drift or volitalization of herbicide could damage desirable crops in adjacent areas.

Some woody species are tolerant to 2,4,5-T but susceptible to 2,4-D and vice versa. Brush killers are used on mixed populations.

Section 6. HERBICIDES AND MIXING OF SPRAY MATERIALS

Some herbicides can be used as they come from the manufacturer. Chemicals such as sodium chlorate can be applied dry or dissolved in water. Others, however, are practically useless in their original form and require formulation before they can be used for weed control.

6.1 FORMULATIONS OF HERBICIDES. A formulation contains the herbicide in a form that can be (1) dissolved or suspended in a carrier and distributed in solution or suspension by sprayers, (2) distributed dry by dusters or spreaders, or (3) easily vaporized for fumigation. Often an emulsifier, spreader, sticker, or other surfactant is added to facilitate dilution or increase wetting capacity. Frequently, formulations contain an inactive filler that serves as a diluent only. For example, there may be only 2, 3, 4, or 6 pounds of active weedkiller in an herbicide formulation that weighs 10 pounds per gallon. There are several types of formulations.

6.1.1 Water-Soluble Concentrates. Water-soluble concentrates are readily dissolved in water to make a spray. They are often sold as solids. TCA; dalapon; sodium salt of 2,4-D and amitrole are examples. They are also formulated as liquids—amine salts of 2,4-D and the sodium salts of PCP and endothall. These liquid formulations are prepared because some water-soluble chemicals cannot be handled conveniently unless they are diluted. For example, the alkanol amine salt of 2,4-D is soluble in water; but at room temperature it is a heavy viscous liquid that would be difficult to measure or mix with water, and when cool, it becomes stiff and unpourable. It is formulated into a free-flowing liquid that easily can be diluted with water and is convenient to handle. Water-soluble concentrates are also available as pastes and slurries—sodium salts of PCP and 2,4-D. They may or may not include wetting agents.

6.1.2 Emulsifiable Concentrates. Emulsifiable concentrates are usually liquids in which the chemical is dissolved in one or more water-insoluble solvents, such as oil or benzene, and to which an emulsifier is added. When the emulsifiable concentrate is added to water and agitated, the mixture is broken into fine droplets. The emulsifying agent causes the fine droplets of oil to be suspended in the water to form an emulsion. The esters of 2,4-D, 2,4,5-T, and silvex are examples. The formulation should be clear, homogeneous, and free from sediment or crystalline solids. It should not corrode equipment and the flash point should not be lower than 140° F. Since emulsions are frequently used in cold weather, the concentrate should have a maximum pour point of -10° F.

The emulsifiable concentrate should disperse readily. A concentrate having poor dispersibility emulsifies only with vigorous agitation, and free oil usually separates from the emulsion on standing a short time. A good emulsion has globules that are

barely visible; one with globules so fine they cannot be seen with the naked eye is better. Such an emulsion is called tight.

The breaking time of an emulsion is also important. Some formulations produce emulsions that break in a few minutes after application, others remain stable for 24 hours. The fast-breaking emulsion requires constant agitation and does not wet leaves adequately. Where constant agitation is impracticable, such an emulsion settles in the tank. Very stable emulsions may not break soon enough, especially in brush spraying, and they tend to drain off the leaf. A good emulsion should contain the solvents and emulsifying agents necessary to keep it stable with hard or soft water during the mixing and application period, but allow it to break soon after reaching the plant surface. As an average, the hardness of water is 322 p.p.m. in terms of calcium carbonate for hard water, 115 p.p.m. for water in municipal systems, and 35 p.p.m. for rainwater.

Emulsifiable concentrates should be stable under both hot and cold storage.

Invert emulsions are water-in-oil mixtures in which every spray droplet is surrounded by oil instead of water. This results in a viscous material difficult to apply but less likely to drift.

6.1.3 Oil-Soluble Concentrates. Oil-soluble concentrates are similar to emulsifiable concentrates, but they do not contain an emulsifier. They do not mix with water; but they can be diluted with fuel oil or kerosene, or applied without dilution. PCP and dinoseb are examples.

6.1.4 Powders and Pastes. Wettable powders or water-dispersible powders are generally formulated from chemicals that are insoluble or soluble with difficulty in oil or water. They are finely ground with or without a powdered diluent. A wetting agent is added to keep the particles from floating, and a dispersing agent is added to keep the material in suspension. Monuron, diuron, and simazine are examples. 2,4-D and 2,4,5-T have been formulated as powders and pastes.

6.1.5 Granules and Pellets. Granules and pellets are forms of herbicides in which the chemical is impregnated upon vermiculite, attaclay, or similar carriers. They can be prepared by spraying the herbicide on the carrier or by adding the core material, such as vermiculite, to the original dry powder. Then a pillrolling technique with binders is used to produce pellets, or the powder plus binders and water is extruded, chopped, and dried to produce grains or pellets. Fenuron, simazine, 2,4-D, and an increasing number of herbicides are formulated as pellets. No water and no mixing are required, application equipment is less expensive than sprayers, and they can be applied in areas awkward for spray equipment. If the chemical is effective only by root absorption, a spray intercepted by leaves is wasteful; grains or pellets that drop to the ground are more effective. However, their cost is higher, they are not adapted for foliar applications but must be applied to the soil, they are generally less effective than sprays where moisture is limited, and distribution of small amounts is difficult except by hand.

6.1.6 Fumigants. Fumigants are volatile compounds, such as methyl bromide, metham, and chloropicrin, that form toxic vapors. Many of these fumigants are discussed individually. Some are injected a few inches below the surface of the soil. An air tight cover is required by some. The vapors penetrate the soil horizon, acting as temporary sterilants that kill plants, seeds, insects, rodents, and disease organisms. After the fumigant decomposes or is dissipated from the soil a crop may be grown.

Fumigants are outstanding herbicides for killing deep-rooted perennial plants such as field bindweed and Russian knapweed. They will also kill weed seeds in gardens, lawns, and nursery beds before planting, or in horticultural beds where trees, vines, or shrubs are to be planted. Sterilization may increase the availability of soil nutrients, and some fumigants contribute chemicals through decomposition that act either as soil amendments or residual toxicants.

Effectiveness of fumigants is highly dependent on characteristics of soil moisture, temperature, compaction, and texture that affect the movement and ultimate distribution of the vapors. Diffusion may be restricted by moist or heavily compacted subsoil layers, shallow hardpans, and heavy claypans.

6.1.7 Adjuvants and Surface-Active Surfactant Agents. Adjuvants are substances added to an herbicide or spray to improve its action. They may be added by the company at the time of the formulation of the active ingredient, or at the time of the mixing of the spray solution before application. Such substances may enhance toxicity, assist emulsification, increase spreading properties, promote leaf retention and penetration, or perform other functions. Certain adjuvants reduce interfacial tension and are known as surface-active agents or surfactants.

Surfactants are adjuvants that bind two or more incompatible phases—such as water and oil—in more intimate contact by modifying the interfacial forces between them. There are various types of adjuvants and surfactant agents.

Wetting agents reduce the interfacial tension and bring a liquid into intimate contact with a solid; as for example, increasing the spread of a contact spray on the leaf surface. Spreading agents are wetting agents that improve spreading properties of water on leaf surfaces.

Emulsifiers are used to maintain the stability of an emulsion. Relative apolar and polar portions of the molecule have affinitives for oil and water respectively. Surfactant molecules orient at the interface between oil and water surfaces, couple them together, and as a result tiny dispersed droplets in a stable emulsion are prevented from coalescing.

Thickening and sticking agents increase spray adherence to leaves and reduce bounce or runoff during spraying. Penetration agents are substances that assist plant absorption of an herbicide. Dispersing agents reduce cohesion between like particles. They play the same role with the solid organic portion of a wettable powder in water that an emulsifier plays in a liquid system.

On many difficult to kill weed species, the use of adjuvants may greatly increase the killing action of most herbicides. However, adjuvants may reduce selective action.

6.2 PURCHASE OF HERBICIDES. Adequate specifications for some herbicide chemicals have been developed. Basically, the economic value of an herbicide depends upon the relative amounts of active chemical toxic to plants that are contained per pound or gallon. This is expressed in percent of active ingredient, acid equivalent, or phenol equivalent for solids, and pounds per gallon for liquids. Thus, a solid containing 74 percent of the weedkilling ingredient is worth more than a 20-percent granular product pound for pound, and an amine salt formulation of 2,4-D containing 4 pounds per gallon, acid equivalent, is of more value than the same formulation containing 2 pounds per gallon. Actually, since mixing charges and cost of containers, freight, and handling have to be paid on twice as much material for a 2-pound-per-gallon formulation as for a 4-pound formulation, the cost per pound of active material is less in the 4-pound formulation than in the 2-pound formulation, although the cost per gallon of product is more.

But this relationship is affected by other factors: under some circumstances, 1 pound of 2,4-D in the ester formulation is twice as effective as 1 pound of the amine salt. This could be true on hard-to-kill species, on many brush species, and in arid climates. Equivalent amounts of the sodium salt are less effective than the amine salts. The amount of chemical that can be packed into a formulation is limited both for physical and chemical reasons, and from an economic stand-point.

Some herbicides are mixtures of several isomers. Often, one is more effective than the others. Although it may not be economically practicable to purify a formulation for the effective isomer, there may be larger proportions of it in one formulation than another. For example, among the polychlorobenzoics, the 2,3,6-trichlorobenzoic acid is more effective on most species than the 2,3,4-; 2,3,5-; 2,4,5-; 2,4,6-; or 3,4,5-trichlorobenzoic acids.

Additives, such as wetting agents, spreader-stickers, cosolvents, and emulsifiers, influence the effectiveness of a chemical. Their precise role and comparative values, however, are not too well understood, and purchase at present must depend largely on empirical information. Carriers of the chemical also vary in cost and in toxicity to plants. Some can reduce the effectiveness of the chemical.

The proprietary mixture of two or more chemicals may be less effective than the constituents applied separately. Because better timing of application can be made of each constituent applied separately than applied together, the effectiveness of the mixture may be less than the sum of individual effects.

Currently, herbicide formulation purchases depend on the relative amounts of active chemical per unit, packaging, freedom from foaming and precipitation problems, and stability under storage. Sometimes, the superiority of a formulation can be demonstrated because of these factors. When Federal specifications are available for all herbicides, purchases can be made on the basis of the requirements stated in the specification

6.3 MIXING OF SPRAY MATERIALS. Mixing spray materials correctly involves calculations of the proper amounts of herbicide and diluent, and procedures for mixing.

6.3.1 Calculations. Rates of application are expressed in terms of acid equivalent for certain herbicides (such as 2,4-D; 2,4,5-T; 2,3,6-TBA; dalapon; and silvex), phenol equivalent for dinoseb and active ingredient for others (such as amitrole and simazine). They are recommended in ounces or pounds per square foot, square rod, or acre where the area to be treated can be measured.

When spot spraying of individual or small clumps of plants is necessary, or where dense foliage, as in brush or trees, is to be thoroughly wet, the concentration of the spray is recommended in pounds of active ingredient or acid equivalent per 100 gallons. Also, in the control of aquatic weeds, concentration of the herbicide is often referred to in terms of parts per million of water. This means the number of parts (by weight or volume) of the chemical in 1 million parts of water or other diluent.

To determine the volume of water in a pond and the amount of chemical needed, use the following:

Average depth of water, in feet, × surface acreage × 43,560 = volume water, in cubic feet, or

Average depth of water, in feet, × surface area, in square feet = volume water, in cubic feet.

1 acre-ft. of water weighs 2,722,500 lb.; that is, 43,560 sq. ft. × 1 ft. = 43,560 cu. ft. × 62 lb. = 2,722,500 lb.

Therefore, 1 p.p.m. = 2.7 lb. chemical in 2,722,500 lb. water (1 acre-ft.).

To determine number of pounds chemical required, use the following:

$$x \text{ (pounds chemical)} = \text{p.p.m.} \times \text{acre-ft.} \times 2.7$$

EXAMPLE: Rate, 5 p.p.m.; volume, 1 acre 2 ft. deep, then $x = 5 \times 2 \times 2.7 = 27$.

Therefore, 27 lb. of chemical would be required for 5 p.p.m. × 2 acre-ft.

Usually, the pounds of active ingredient or acid equivalent per gallon are given on the label of liquid herbicide. The percent is given on labels of powders, granules, and other dry materials.

To calculate the amount of liquid herbicide required when the rate is expressed in pounds per acre, use the following formula:

$$\frac{\text{Rate in pounds per acre}}{\text{pounds of herbicide per gallon}} = \text{gallons per acre}$$

EXAMPLE: If the rate is 1 1/2 pounds per acre and the herbicide contains 4 pounds per gallon, then

$$\frac{1.5}{4.0} = 0.37 \text{ gallon, or 8 pints} \times 0.37 = 3 \text{ pints.}$$

Use the same formula to calculate gallons of herbicide per 100 gallons of spray.

EXAMPLE: If the rate is 2.5 pounds per 100 gallons and the herbicide contains 2 pounds per gallon, then 2.5/2.0 = 1.25 or 1 1/4 gallons.

To calculate the amount of dry product required when the rate per acre is given, use the following:

$$\frac{100}{\text{percent active ingredient}} \times \text{rate per acre} = \text{pounds product}$$

EXAMPLE: If the rate is 15 pounds, active ingredient, per acre, and the percent of active ingredient is 75, then 100/75 × 15 = 20.

A list of equivalents in measures, weights, and rate of speed is given (Appendix, p. A-1)for convenience. Equivalent temperatures on Centigrade and Fahrenheit scales are given, p. 162.

6.3.2 Tank Capacity. To calculate capacity of the sprayer tank (all measurements in inches):

Cylindrical tanks: multiply length × square of diameter × 0.0034 = capacity in gallons.

Tanks with elliptical cross section: multiply length × short diameter × longer diameter × 0.0034 = capacity in gallons.

Rectangular tanks with square or oblong cross section: multiply length × width × depth × 0.004329 = capacity in gallons.

If tank capacity is not known, it can be determined in a practical way by filling the tank with water and then emptying it into a measure of known capacity, such as a 1- or 5-gallon container.

Never pour the concentrate into an empty tank. Either fill the tank half full, add the chemical, agitate, and complete the filling; or start filling and add the chemical as the filling is continued. Operate the sprayer with the nozzles shut off, bypassing the spray through the tank for several minutes (at least six times) to insure a thorough mixing.

6.3.2.1 Water sprays. When using a soluble powder or crystals, fill the tank half full of water. Add the chemical slowly, and stir to dissolve it completely. If a detergent is recommended, add one-quarter to one-half pound of household detergent per 100 gallons spray. If a solid grasskiller is to be used with 2,4-D or 2,4,5-T, mix it with water first and then add the 2,4-D or 2,4,5-T. Use the spray solution within 1 or 2 days after mixing, since some chemicals lose strength on standing.

If an amine salt of dinoseb is used in very hard water, add 1 pound softener per 100 gallons spray.

6.3.2.2 Emulsions. Since emulsions are suspensions and not solutions, they require constant agitation. If no additional oil is to be used, start running water into the empty tank and slowly add the herbicide formulation with continuous agitation. The chemical should all be added by the time the tank is one-third full.

If oil is to be used, premix the herbicide and the oil in a separate container. Do not allow any water to get into this mixture or it may jell. Fill the tank one-third full of water, add premixed oil and herbicide, and continue filling. Agitate constantly. The water should be clean and low in carbonates and sulfates. (If ordinary hand soap lathers well, the water is satisfactory.) Circulate the mixture until it is uniformly white. If the emulsion stands for several hours, stir until uniformly white before using. Take samples of the emulsion from various sections of the tank at intervals to determine if separation has taken place.

When an invert emulsion is used, add water slowly to the premixed herbicide-oil solution under constant mechanical agitation; circulating with bypass is insufficient. Invert emulsions may separate readily on standing. After 24 hours of separation, most invert emulsions cannot be restored.

6.3.2.3 Oil sprays. Add esters of 2,4-D, 2,4,5-T or silvex, or other oil-soluble herbicides to the required amount of oil, and mix thoroughly in the tank. This can be done at any time before spraying, since the spray does not separate. Do not let any water or oil-water mixture get into the chemical formulation or the herbicide-oil mixture, or it may jell.

6.3.2.4 Suspensions. Water-dispersible powders mix readily with water but do not dissolve. There are two methods of mixing: (1) add the powder slowly to water, with agitation—it should not be added to an empty tank—or (2) make a thin water slurry of the required amount of material before it is added to the water in the tank. A thorough job of mixing will help the agitator do its job more efficiently.

When esters of 2,4-D are used with monuron or diuron, add one-half pound of a caseinate conditioning agent to the suspension before adding the 2,4-D ester.

When a water-soluble chemical is to be mixed with a water-dispersible powder, dissolve the water-soluble chemical in the water before adding the powder.

6.4 STORAGE OF HERBICIDES. A chemical with a low flash point (40°F or less) is dangerous in storage.

Deterioration of chemicals in storage can be prevented by observing the following precautions.

Dusts and wettable powders present no problem as long as they are kept clean and dry. They cake when wet, and packages may deteriorate. Water-soluble solids also cake when wet and when subjected to great changes in temperature. If packages are left open, hygroscopic chemicals become wet by absorbing water from moist air. Such chemicals as TCA, dalapon, PCP, chlorates, borates, and ammonium sulfamate cake when they are wet.

Liquid formulations should be stored on pallets or duckboards to keep the metal containers from rusting. The containers should be tightly closed. Air vents, punched in cans to facilitate pouring, should be plugged. Even small amounts of water introduced into emulsion concentrates or oil solutions can make them jell and cause deterioration of the container.

Chemicals may crystallize out of solution at temperatures below 32°F. If this happens, warm the products to 40°F. or higher and roll the drums or shake the containers. If the crystals return to solution, no harm has been done. The following formulations do not freeze if stored in unheated rooms: Low-volatile esters of 2,4-D; 2,4,5-T; 2,4-D plus 2,4,5-T (brush killer); and silvex and the alkanol amine salt of dinoseb. The following formulations may crystalize out of the solution if stored at temperatures below those indicated:

	°F.
2,4-D, alkanol amine salt	15
2,4-D, dimethylamine salt	20
2,4-D, butyl ester	23
2,4-D, isopropyl ester	32
2,4,5-T, butyl ester	47
2,4,5-T, amine salt	34
2,4-D plus 2,4,5-T, butyl ester	18
2,4,D plus 2,4,5-T, amine salt	43
MCPA, amine salt	14

	°F.
Dinoseb, emulsifiable oil concentrate	20
Dinoseb, ammonium salt	32

At high temperatures, chemicals may expand and cause bulging of drumheads and leaks in the containers. They may deteriorate at temperatures over 95°F. High temperatures may reduce the effectiveness of emulsifiers and hasten the corrosion of containers.

Section 7. APPLICATION EQUIPMENT

The results that follow the use of a herbicide depend largely on how well or how poorly it is applied, and this in turn depends on the operator and his equipment. Equipment is designed to apply herbicides (1) wet, in sprays or mists; (2) dry, in dusts or granules; and (3) in readily vaporized form for fumigation.

7.1 GROUND SPRAYERS.

7.1.1 Hand Sprayers. Hand sprayers are suitable for treating small patches inaccessible areas, and fence rows; for spot spraying; and for situations where the spray is to be applied close to susceptible plants. They include sprinkling cans, compressed-air sprayers of 1- to 5-gallon capacity carried by a strap over the shoulder, and knapsack sprayers with hand-operated pump. In the ordinary compressed-air sprayer, the pressure is reduced as the tank is emptied; but there are constant-pressure types. Some models, useful on trails, have cylinders of CO_2 gas to provide pressure. Knapsack sprayers are more expensive than compressed-air sprayers, but they have an agitator attached to the pump that makes them more suitable for suspensions. (See Figure 2.)

Trombone-type sprayers are very versatile. They are especially adaptable for spraying tall trees.

Water-dispersible powders that form suspensions of high concentration in water tend to clog flat spray tip nozzles; a cone type gives less trouble. Compressed-air and knapsack sprayers are well adapted for herbicide concentrates to be used along highways. The cone oil-burner type nozzle that delivers 2.5 to 6 gallons per hour at 20 to 30 p.s.i. is very suitable. The solution or emulsion at 20 times usual concentration is applied at the rate of 5 to 6 gallons per acre for low-growing vegetation or 12 gallons per acre for heavier brush. A hood around the wand or boom prevents drift onto sensitive plants nearby.

7.1.2 Boomless Sprayers. Boomless sprayers—nozzle-cluster type—are well adapted for spraying roadsides and ditchbanks, under utility lines, and along fence rows. They are less expensive, simpler to operate, and have less nozzle trouble than boom sprayers. They can pass between trees and shrubbery, they can be maneuvered close to other obstacles, and they are practical for rough ground. They spray a broadcast swath of 20 to 30 feet with large volumes that provide moderately good coverage.

For foliage sprays, the conventional equipment consists of a piston-type hydraulic sprayer, such as the Hardie, Bean, Iron Age, or Myers, equipped with 3/4-inch high-pressure hose and 15 g.p.m. (gallon per minute) pumps for a 3/16-inch nozzle opening, or 35 to 60 g.p.m. pumps for 1/4-inch, 5/16-inch, and 15/16-inch nozzle openings.

FIGURE 2
Hand Sprayer for Small Areas

The equipment is mounted on a four-wheel-drive power wagon or caterpillar-type tractor. The chief disadvantage of the boomless sprayers is that the spray stream is greatly affected by the wind. They should not be used when the wind may cause drift to sensitive vegetation nearby.

7.1.3 Boom Sprayers. Boom sprayers are adapted for large areas where complete coverage is necessary, or for turf areas adjacent to a road where the entire application can be made from a tractor or truck-mounted boom (See Figure 3.)

For roadside or ditchbank spraying, arm booms are available. One end of a shaft is fastened to the truck and the other end terminates in a boomless sprayer nozzle. A two-nozzle arm boom is used for ditchbanks. A larger boom can be set at right angles to the truck for roadside or ditch spraying, or vertically to spray above tall weeds. For roadside spraying, two or more nozzles are grouped together and mounted on an arm that reaches over mailboxes, highway signs, etc. A truck-mounted boom designed to spray under guide rails reaches over them and sprays from the outside toward the pavement. Nozzles mounted off center enable the operator to spray 15 to 20 feet on one side.

Hand booms and adjustable spray guns are operated from truck-mounted power spray equipment and are used for application of basal sprays and stump treatments, for brush control and spot treatments, and for spraying around structures of various kinds. Handguns are used with pressures of about 100 p.s.i. Increased pressures result in a larger proportion of fine droplets and drift is increased. Handguns can vary delivery from a broad mist to a narrow coarse stream. Instead of a single nozzle, a bank of three to eight can be used. Sometimes the conveyor truck is stationary and long lines of hoses and side hoses are used to reach the area to be treated.

7.1.4 Mist Blowers. Mist blowers are power-driven machines that disperse highly concentrated sprays in finely atomized form at low volumes per acre. The herbicide is carried principally in an airstream instead of a liquid. These sprayers are free from boom and nozzle troubles, and are very useful to spray herbaceous weeds and woody plants in swamps, under fences, around stone piles, along roadsides, in drainage ditches, and under powerlines. Mist blowers require minimum amounts of water, they cover vegetation rapidly, and they can be used for areas inaccessible to power equipment. The equipment is cheaper than the conventional hydraulic power equipment. Use of mist blowers for weed spraying, however, is limited by the serious hazard of drift. Mist blowers in 5- to 12-h.p. (horse power) sizes are useful for brush spraying, if drift is not a problem. A 2-h.p. knapsack mist blower is useful for brush up to 30 feet tall, for spot spraying, and for re-treating.

7.1.5 Special Equipment. For spraying berm and adjacent weeds and brush—a right-hand drive truck with four nozzles mounted on a 6-foot sturdy vertical beam. A low-position, solid-stream nozzle with a 3/16-inch opening sprays berm to 24 feet from the machine, and three fan-type boomless nozzles spray brush and weeds close to the machine. The pump delivers up to 20 g.p.m. at 800 p.s.i. from a three-speed power takeoff. The whole operation is controlled by the driver of the truck. The sprayer delivers from 25 to 50 gallons semiconcentrated material per mile of road.

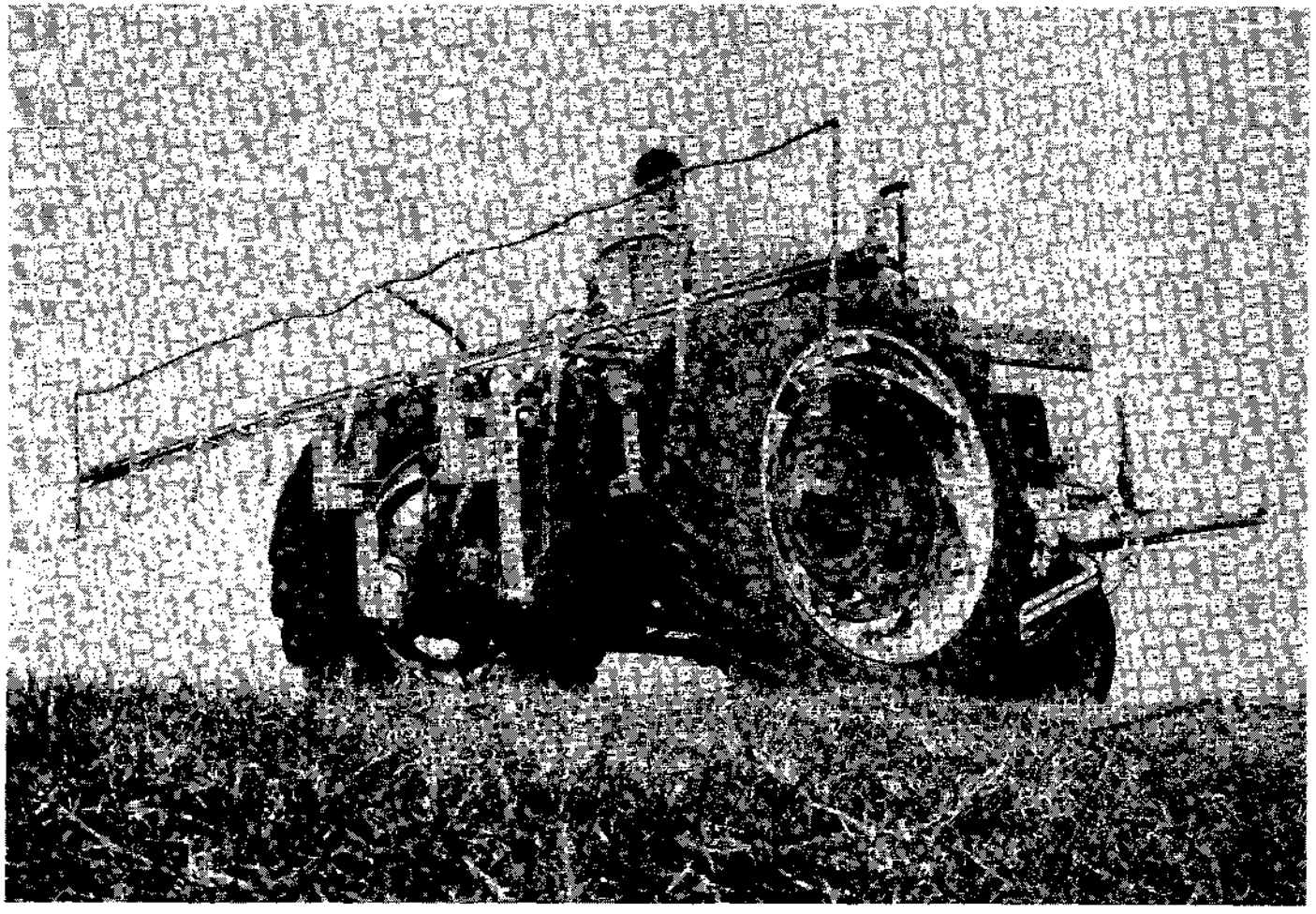


FIGURE 3
Tractor Mounted Boom Sprayer

For spraying around guardrails and posts—a truck-mounted tank with power sprayers and a boom mounted on the right side of the truck. The boom is controlled by an operator sitting next to the driver. The control valve is hand-operated. There are two nozzles; one sprays on each side of the guardrail or post.

For treating shoulders or fireguards—a boom operated hydraulically or electrically makes it possible to raise or lower it over obstructions, posts, and slopes. The boom for shoulder applications is about 8 feet long; for fireguards, 12 feet.

For basal-stem treatment—a 4-h.p. gas engine and 1/2-inch gear pump, and two lines of light hose with suitable nozzles, gun, and shutoff valve attached to each line of hose. The spray is five times the concentration of dilute sprays. A simple device is a 2-gallon can—called a "trickler"—carried on the operator's back, that allows the chemical to flow by gravity through a flexible tube to a light wand. The discharge is controlled by a leakproof valve.

For brush, briers, and small trees in fence lines and on ditchbanks—a tractor-powered, high-pressure sprayer for spraying foliage. It may be equipped with a nylon-roller or other high-pressure pump, 25 feet of high-pressure hose, and an adjustable spray pattern handgun.

7.1.6 Individual Parts.

7.1.6.1 Pumps. Pump capacity should be about twice the nozzle delivery rate to provide for an overflow that is bypassed back to the tank for agitation of the spray. The several types are:

(1) A rubber-impeller pump is cheap, is not injured by abrasive suspensions, develops about 35 p.s.i., but is not adapted for oils.

(2) A rotary gear pump has positive action. The discharge rate depends on the speed of rotations. Suspensions are hard on the gears. Plastic gear pumps can be replaced more cheaply than repairing permanent equipment.

(3) A centrifugal pump is a single-rotating impeller type. It pumps a large volume of spray but does not develop a high pressure—40 p.s.i. to 70 p.s.i. It can handle all spray materials with minimum wear. It is not self-priming so must be mounted lower than the tank. Unlike most pumps, it pushes the liquid in one direction only.

(4) A piston pump is designed for large quantities of spray and high pressures—up to 1,000 p.s.i. It has one or more plungers connected to a crankshaft. The plungers or pistons work inside smooth cylinders. The piston pump can be used for any type of sprayer, stands rough treatment, and is long lasting but expensive.

(5) A nylon-roller pump gives good service, but it is expensive and is not well adapted for suspensions. It pumps only after reaching a high speed.

(6) A diaphragm pump is similar to a piston pump except that one side of the chamber is made of a flexible fabric that creates the vacuum. This pump handles abrasives well, but the fabric does not always last long under the pressure normally required for spraying. The diaphragm, however, can be replaced easily and economically.

7.1.6.2 Tanks. Tanks should be easy to clean and rustproof. Other desirable features are: a wide mouth with 12- to 16-mesh removable strainer; a round or trough-shaped bottom with a drain in the lowest part; a paddle-type agitator that moves slowly, sweeps the bottom, and can be disengaged; and an auxiliary 1- to 3-gallon graduated flush tank for quick flushing of the spray line, which can also be used for small quantities of spray. The tank should be calibrated in 5-gallon increments with an unpainted and unvarnished measuring stick. A shutoff valve should be placed immediately below the tank to prevent spray material from settling in the spray line, strainers, and nozzles.

7.1.6.3 Pressure regulators. Bypass regulators are necessary for gear, nylon-roller, diaphragm, and reciprocating piston pumps; diaphragm regulators, for centrifugal or impeller pumps. The bypass regulator allows excess liquid to flow back to the tank; with proper adjustment it can maintain a constant pressure at the nozzles. Neither a spring-loaded ball-type high-pressure relief valve nor a hand-operated bypass valve functions correctly as a pressure regulator. The regulator should be a sensitive spring-loaded type for high pressures, and a disk or diaphragm type for pressures up to 175 p.s.i.

7.1.6.4 Valves, pressure gage and strainers. The shutoff valves should be fast, easily accessible, and of the same diameter as the main boom line. Dripping may be reduced or prevented by (1) special spring-activated valves that automatically close with reduced pressure, installed between each nozzle and the boom; or (2) venturi tubes and shutoff valves, arranged to cause a suction from the nozzles into the boom when the supply is cut off.

The pressure gage should be mounted where it is easily seen by the operator and should be large enough to be read easily.

Strainers in the boom line should be placed so as to intercept solid particles before they reach pump, pressure regulator, or nozzle. A 50- to 80-mesh screen should be installed in the suction line to the pump. A strainer of 100- to 150-mesh and about 100 square inches in area should be placed between pressure regulator and boom when emulsions or solutions are used. Nozzles require individual screens: a 50-mesh for tips of greater capacity than 0.1 gallon per minute, and 100-mesh for smaller tips. Nozzle screens should have mesh openings only slightly smaller than the nozzle opening, so fine particles may pass through.

7.1.6.5 Hoses and fittings. Hoses should be strong enough to withstand the pressure to be used, and of a material not deteriorated by spray solutions and oil. Ordinary garden hose stands about 70 p.s.i. The hose on the intake side of the pump should be at least one-half inch in diameter. The discharge hose from pump to pressure regulator should be of the same size. The discharge hose from the pressure regulator to the

nozzles can be smaller, but it must be large enough to feed at least twice the number of nozzles being used. Too small a hose results in reduced pressure at the distant nozzles. Pipe fittings should be resistant to corrosion. Eyelet fittings are more desirable than welded.

7.1.6.6 Booms. Booms should be adjustable for height, and the tube that carries the spray should be noncorrosive. In booms with large diameters, the spray liquid does not flow so rapidly as in those with smaller diameter. When a suspension is used, the powder may settle in the boom if the flow is too slow. Valves at the outer ends facilitate cleaning. Dry booms are supports for a separate hose or tube that carries the spray liquid to the nozzles. Small booms can be used for hand sprayers instead of a wand. A funnel slipped over the nozzle on the end of a wand confines the spray to a small area and prevents contact with nearby plants.

7.1.6.7 Nozzles. Nozzles are of two general types—those with removable tips, and those whose tips are an integral part of the nozzle. Removable tips are convenient. Tips are designed to produce a flat, fan-shaped spray or a cone-shaped spray. The fan-shaped is the more accurate in volume delivery, and produces a spray that covers more uniformly than the hollow-cone type on the average boom sprayer. The fan-type with tapered edges sprays more uniformly on a boom than the preemergence or band-spray type with squared edges. Cone-shaped nozzles do not clog so easily as flat-spray types, especially when the spray is a suspension.

Broadcast nozzles spray a wide swath. They are used singly and in clusters to cover a width of 20 to 30 feet and, under some conditions, up to 60 feet. Uniform spray patterns are difficult to obtain, especially if there is a wind.

The most widely used fan-type nozzles are the flat atomizing group of which Tee-Jet is an example. They come in spray angles of 110° to 15° or even in a solid stream. Spacing on a boom is usually 20 inches. On the nozzles of some companies, the first two digits of the number on a flat-spray tip indicate the spray angle, the latter two indicate the capacity in gallons per minute at 40 p.s.i. Numbers on cone-spray tips designate the capacity only at 10-, 40-, or 60-pound pressure and depend on the tip design. The spray angle is directly associated with design and the line pressure, and is stated in the manufacturer's specifications.

Flooding types of flat-fan nozzles deliver a spray whose droplets are about one-half larger in diameter than those delivered by the conventional flat-fan nozzles, which produce a spray pattern of larger droplets than those produced by the hollow-cone or full-cone types.

The smaller the opening, the finer the droplets if the nozzle design and pressure are the same. Larger openings can be used for any method of application by (1) widening the nozzle spacing on the boom, (2) increasing the spray volume per acre, (3) increasing the rate of travel, or (4) decreasing the pressure.

Use flat-spray offcenter 3/4-inch tips for ditchbank weeds. Use 1/4-inch offcenter tips for directed basal sprays. Use two small fan-type tips in a double swiveled nozzle for hard-to-wet foliage instead of one larger sized tip; e.g., two 8002's instead of one 8004.

7.2 AERIAL SPRAYERS. The obvious advantages of aerial spraying are offset to some degree by the hazards to the pilot and the damage from drift. A complete discussion of aerial equipment may be found in Concentrated Spray Equipment, Mixtures and Application Methods, by Samuel F. Potts, Caldwell, N.J., 1958. A summary of pertinent information follows.

A helicopter needs no runway and can fly better in low visibility than light fixed-wing aircraft, but it is more expensive.

Drift can be reduced by (a) flying in calm weather, (b) using low-volatile chemicals, (c) using nozzles with large openings, (d) using water or emulsions instead of pure oils, and (e) using low pressures. A positive shutoff valve for each nozzle will avoid damage from dribble. (See Figure 4.)

7.2.1 Tanks. Tanks are made of stainless steel, aluminum, galvanized iron, or molded plastic. Removable tank liners of synthetic rubber or plastic shorten cleaning time and avoid contamination when different chemicals are used. Tanks should have large filler necks to eliminate need for a funnel and to facilitate cleaning. Use a removable fine-mesh screen to catch sediment.

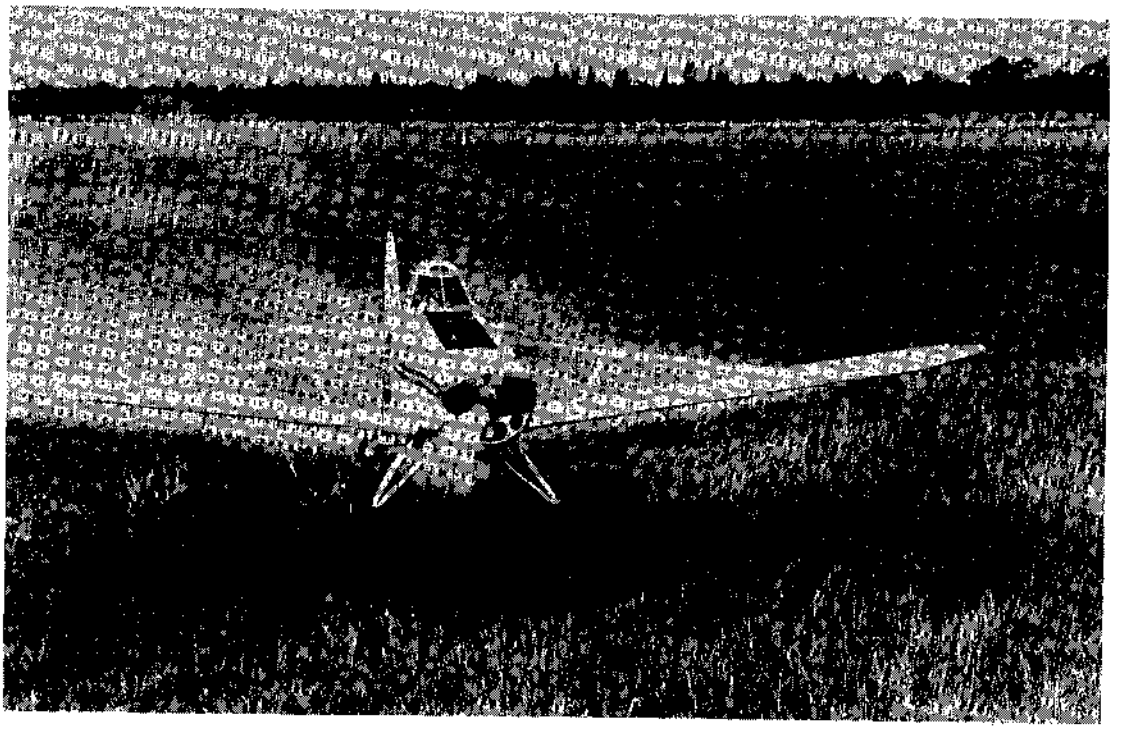
7.2.2 Pumps. Centrifugal pumps handle all kinds of spray chemicals with least wear, but they push the liquid in one direction only. They must be mounted below the tank, or some priming arrangement must be provided. Turbine types develop higher pressures and move the spray in either direction, but they have to be mounted lower than the tank or be primed by hand.

Gravity feeds are satisfactory for herbicides applied as coarse sprays or atomized by devices other than standard nozzles. The pressure and rate of flow decrease as the tank is emptied.

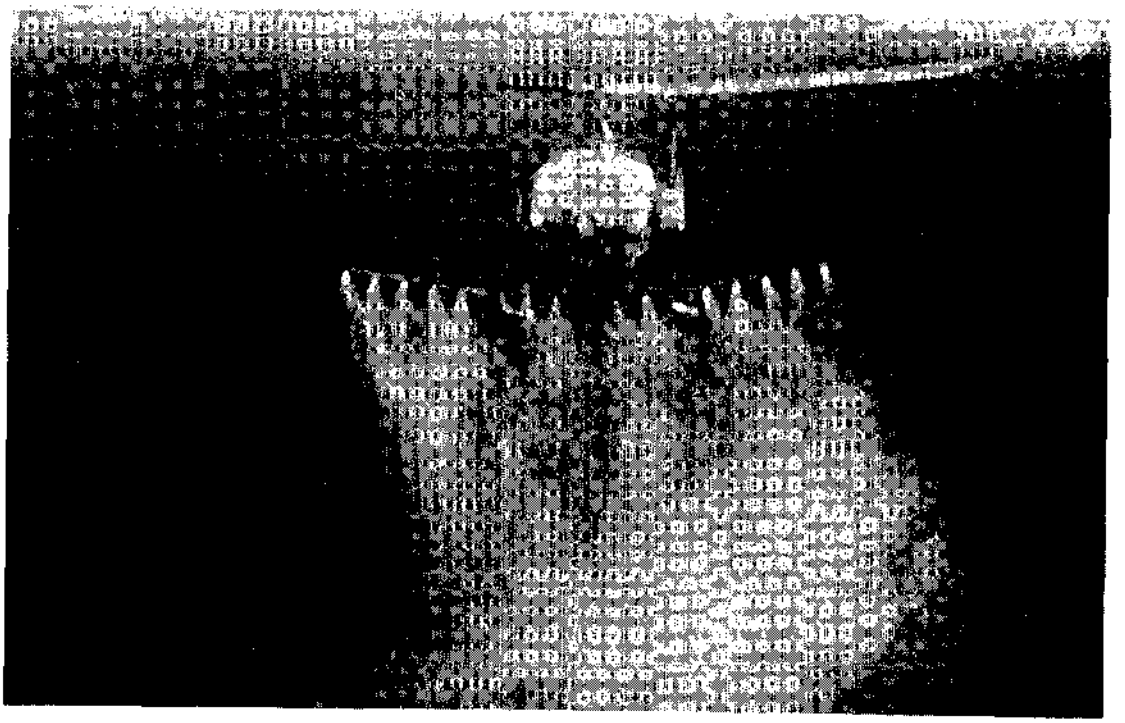
Pump materials must be rust resistant. Operate the pump from wind-driven propellers, hydraulic motors, electric motors, or the accessory drive pad of the engine.

7.2.3 Pipes, Fittings, and Valves. Pipes are made of aluminum, stainless steel, or plastic. Hoses must be resistant to aromatic fuels; fittings should be dural or brass-flare type. Main-line valves should be quick closing; nozzles require nondribble shut-off valves.

7.3 DUSTERS AND SPREADERS. The use of dry materials, especially granular formulations instead of sprays, is increasing. Where water is not readily available, dusts are substituted for sprays and applied with various kinds of dusters from hand-operated to power-driven machines. Dusters are simple to operate, can be filled rapidly, and



(a) By Fixed-Wing Aircraft



(b) By Helicopter

FIGURE 4
Spraying With Aircraft

travel at faster speeds than sprayers; but drift is a serious problem, and application of herbicidal dusts is prohibited by law in some States.

Granular products are more practical than dusts in most situations. Application is made by hand, with broadcast seedsowers, with fertilizer spreaders (both small and tractor-drawn), or with air-gun applicators.

A typical hand spreader has a rotating plate powered by a handcrank for spreading the granules. It is carried by a shoulder sling strap, weighs 6 pounds, has a capacity of 25 pounds, and is adjustable for various rates. The rotary type of spreader handles heavy formulations effectively, but it is not as satisfactory for formulations based on lighter materials such as vermiculite.

Granular herbicides such as fenuron are applied to brush by hand. Typical equipment consists of a 10-quart pail and plastic spoon for each member of a crew, and a 2-ton crawler tractor that pulls a "scoot" (a sled-type carrier with steel runners 6 inches wide and 24 inches clearance) equipped with a 7 1/2 x 4 foot box for hauling bags of chemical. The tractor and "scoot" are driven along the highway, the crew (10 men) spread out across 70 feet and, as they walk, throw a teaspoon of fenuron beside each brush cluster. Where brush is thick, the crew uses the grid system throwing a teaspoon of chemical every 3 feet.

7.4 APPLICATORS FOR SOIL FUMIGANTS. Applications of soil fumigants are made with sprinkling cans, spreaders, hose proportioners, soil injectors, and inexpensive applicators that puncture the can of such fumigants as methyl bromide and gasket the openings. Saran tubing, evaporating pans, and a gasproof cover are necessary for chemicals requiring cover. Applicators and other equipment are available from distributors and dealers.

Section 8. REQUIREMENTS FOR DIFFERENT TYPES OF SPRAYS

8.1 OILS. All hose connections should be made of teflon or a neoprene type material. The tank need not be heavy walled or equipped to operate under pressure. The pump should be milled with very close tolerances; it should not require lubrication. Pumps that depend upon packing and repacking to prevent leakage are not satisfactory for application of oil.

8.2 EMULSIONS. The pump described for oils is satisfactory for emulsions. Internal rotary gear pumps, diaphragm, piston, and nylon-roller types are adaptable to oil-water emulsions for spraying ditchbank weeds.

8.3 SUSPENSIONS. For small areas, use lawn sprinkling cans or knapsack sprayers. Keep spray mixture well agitated. With knapsack sprayers, use either cone-type or fan-type nozzles. Often small booms with two to four nozzles spaced 20 inches apart are useful. Skips or unneccessary overlapping can be avoided by marking off small areas to be covered at a time.

For large areas, use power equipment. Agitate the spray mixture continuously so that the chemical does not settle out. Mechanical agitation is usually adequate, but it is ineffectual if the power unit is idled or operated at reduced speeds. Check the effectiveness of the agitation by watching for any powder left in the corners of the empty tank. Effective suspension of water-dispersible powders can be obtained with hydraulic agitation provided from bypassed spray materials if the pump has sufficient capacity.

To construct a jet agitator, install a pipe on the nozzle supply side of the pressure regulator and extend it to and along the bottom of the tank to reduce foaming. One pint of kerosene per 100 gallons spray is an effective antifoaming agent. Fit the pipe with sufficient jet-agitator nozzles, or drill holes in the pipe, to maintain turbulence. Recirculate the solution through this pipe at about 10 percent of the tank capacity per minute. A second return line, leading from the pressure regulator to the bottom of the tank, must also be used for pressure regulation. Use no finer than a 50-mesh screen or strainer when powders are used.

Gear pumps wear out quickly when used for suspensions of wettable powders. A piston pump, driven by a separate engine or a diaphragm pump, is more dependable. Most portable units use a roller pump. Where tractors or trucks with power takeoff are to be used, a good roller pump or diaphragm pump is satisfactory.

Pumps for power-takeoff mounting deliver volumes roughly in proportion to the speed of the shaft. Standard maximum power-takeoff speed is about 540 r.p.m. If the speed of the power-takeoff shaft is not maintained near maximum, pump volume drops off. Since large pump capacities are necesary if the volume for both adequate spraying

and agitation is to be maintained, it is important to spray with the vehicle throttle set as near maximum as possible. If the pump does not have enough capacity to supply both the agitator and the desired number of nozzles, reduce the ground speed of the vehicle by changing to a lower gear and use smaller nozzles demanding less volume.

Maintain a pressure range of 30 to 60 pounds when a boom attachment is used. For hand-operated spray guns with larger nozzles, increase the pressure. Since some small pumps have maximum outputs of 4 to 5 gallons per minute, it is impossible for them to recirculate 10 percent of a 55-gallon tank per minute and furnish additional capacity for spraying. Use a pump with capacity sufficient to furnish 4 to 5 gallons per minute to the boom in addition to the volume needed for the agitator if hydraulic agitation is to be used. (See Figure 5.)

A spray boom, mounted on a tractor or some other vehicle, provides one of the most accurate and rapid methods of application. A large area can be covered quickly, and the spray equipment can be calibrated accurately. In booms with large diameters, the spray liquid does not flow so rapidly as in small-diameter booms, and the powder may come out of suspension and settle in the boom. For average equipment, use booms 3/8 to 1 inch in diameter; the size depends on the length of the boom, the screen, and the size of the nozzles. For blanket spraying with nozzles at 20-inch spacing along the boom, the tips should be about 18 inches above the ground or tops of the weeds for 80° nozzles, and 21 inches for 70° nozzles. These nozzle heights provide for a little overlap of the spray pattern between nozzles; this assures a uniform and continuous swath.

Use a 50-mesh, or coarser, filter screen for the suction strainer and the line strainer. For the individual nozzles, use screens with only slightly smaller openings than the nozzle opening. Do not use flannel or cloth filters.

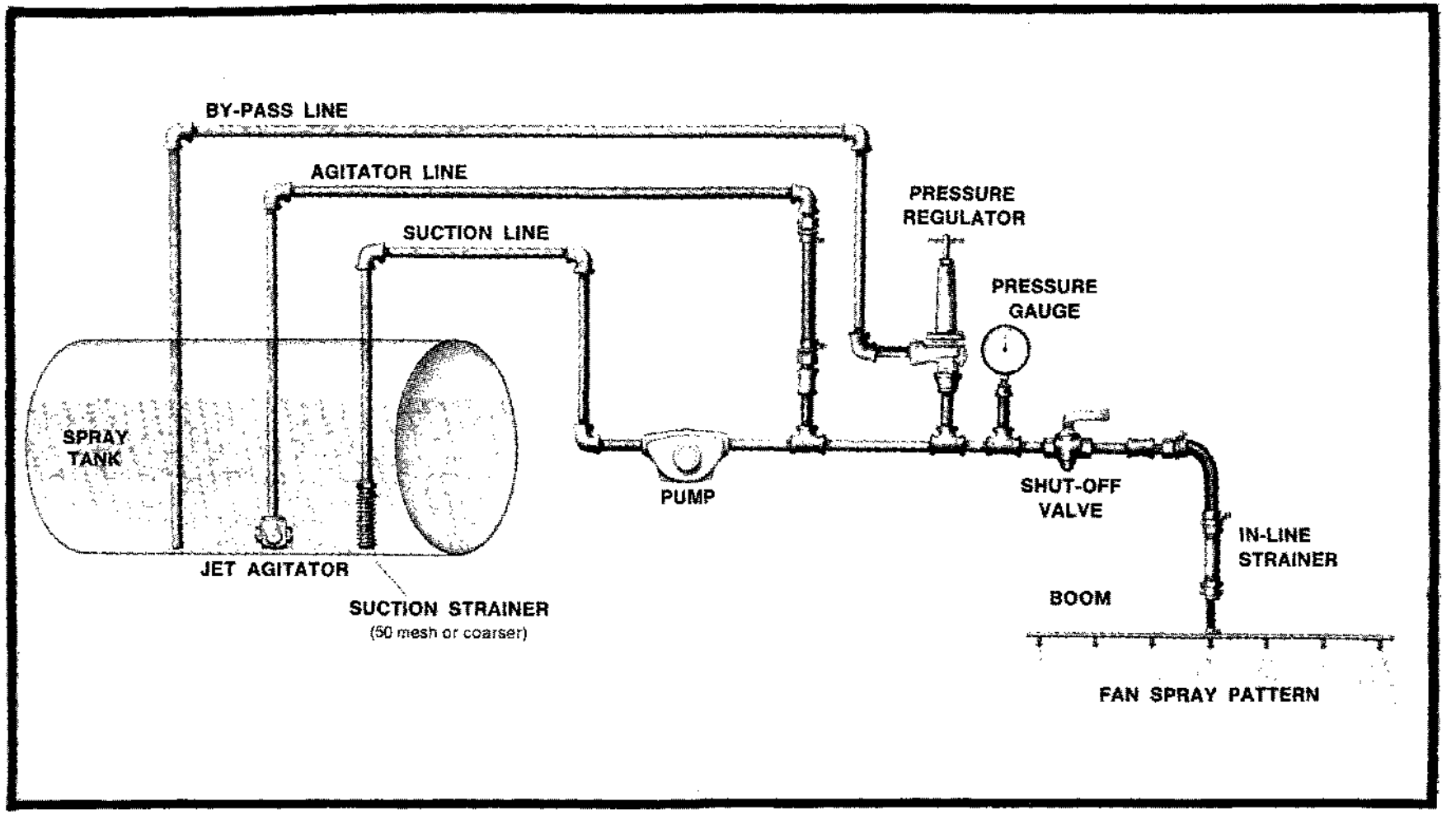


FIGURE 5
Diagramatic Representation of the Components of a Sprayer System

Section 9. OPERATION

To a large extent, the proper adjustment and calibration of spray equipment determine the success of a spraying operation. Keep the nozzles clean, and keep the volume per acre constant. Never use a metal object to clean nozzles; an old toothbrush cleans without injuring the orifice. The volume can be varied by changing the pressure, the speed of travel, or the nozzle size.

9.1 REGULATING VOLUME. A change in pressure results in only small changes in volume. To double volume, it is necessary to increase the pressure four times. The more convenient ways to change volume are to change the speed of travel or to change the nozzle tip. Doubling the speed reduces volume one-half. The amount of spray delivered by a nozzle is directly proportional to the square of the diameter of the opening. Thus, doubling the diameter of the opening increases the volume four times. Charts are available from spray-equipment companies showing capacities of nozzle size in gallons per minute at different pressures. Some charts give gallons per acre at designated speeds.

Even after selecting the proper nozzle, calibration is necessary. Nozzle output may vary considerably from the charted capacity. Calibration is not necessary where rates of application are given in pounds herbicide per 100 gallons spray, and the amount applied depends on density of foliage or stems as in brush spraying with handguns.

9.2 REGULATING DROPLET SIZE. The smaller the droplets, the slower they fall, and the greater the chance of drift. The lower the pressure, the larger the average size of droplet. With a typical flat-fan nozzle, a decrease in pressure from 60 to 20 pounds per square inch can double the size of the average droplet. It can also decrease by four or five times the number of fine droplets.

To reduce the drift hazard, never use less than 10 gallons per acre. Use 20 to 30 pounds' pressure for broad-leaved weeds. Keep nozzles as close as possible to the top of vegetation or the ground while maintaining a complete coverage within the swath. The boom may be lowered by rotating its axis so that nozzles spray backward or forward at an angle onto the foliage rather than straight down. A high ground speed allows use of larger nozzles for a given volume per acre. A high ground speed plus high gallonage plus low pressure permits the use of nozzles with large openings; hence, the droplets will be coarser and there will be less drift. Use a flooding type of nozzle if susceptible plants are nearby. Never increase output of the sprayer by raising the pressure; change to a larger size nozzle. Use smoke trails to determine wind direction.

9.3 CALIBRATION OF EQUIPMENT. Both hand and power equipment require calibration for the conditions under which they are to be used. The manufacturer's calibration is made in the laboratory or factory and may not apply to field conditions. Furthermore, spray delivery changes as the machine becomes older—parts become worn and strainers and screens become partially clogged.

9.3.1 Hand Sprayer. The volume of spray per square rod or per 1,000 square feet in which the chemical can be applied depends on the size of the nozzle, nozzle spacing, and the speed at which the operator walks. To calibrate the sprayer, measure out a plot 1 square rod or 1,000 square feet in area. Spray the plot with water in the equipment to be used and at the normal walking rate of the operator. Measure the water used. Convenient volumes for calculations are 1 pint per square rod (20 gallons per acre), or 1 quart per square rod (40 gallons per acre), or 2 quarts per 1,000 square feet (22 gallons per acre). The amount of chemical recommended for treatment is then mixed or dissolved in the volume of liquid thus determined.

9.3.2 Power Sprayers—Boom Type. Before proceeding to calibrate a sprayer, do the following: (1) run water through the sprayer to see that all nozzles are clean; (2) check to see if they discharge at a uniform rate by running water through them at uniform pressure, catching the discharge from each nozzle in a separate container (such as a calibrated nursing or baby bottle). If the discharge varies widely, replace nozzle tips.

Determine the amount of herbicide to put in the tank by one of the following methods.

(1) Determine the amount of liquid a sprayer applies per acre as follows:

(a) Start with a tank filled to the brim with clean water. Adjust the pressure to what will be used in the field.

(b) Drive exactly one-eighth mile (40 rods, or 660 ft.) in a field or along a road, ditchbank, or other area to be sprayed at the speed to be used when spraying—usually 3 to 5 miles an hour. Measure from where the spray begins, not where the tractor started. Operate the tractor at full throttle. Set speed by selecting right gear (so governor can maintain constant speed under variable loads).

(c) Shut off the spray, return to the original filling position on level ground, and refill the tank. Measure the amount of liquid required.

(d) Calculate the application rate as follows:

$$\frac{\text{Number of quarts used} \times 16.5}{\text{width of spray swath, in feet}} = \text{gallons per acre}$$

EXAMPLE: If 6 quarts of water were used in one-eighth mile and the spray width is 20 feet, multiply 6 by 16.5 and divide by 20. The result is 4.95, or about 5 gallons per acre.

$$\frac{6 \times 16.5}{20} = \frac{99}{20} = 4.95 \text{ gal. per acre}$$

Divide the number of gallons the tank holds by the number of gallons the sprayer applies per acre. This gives the number of acres one filling will spray. Multiply the number of acres one tankful will spray by the amount of herbicide to be used per acre. This gives the amount of herbicide to be used for each tankful.

EXAMPLE: If the tank holds 55 gallons and the sprayer applies 5 gallons per acre, one tankful will spray 11 acres (55 divided by 5). If 1 pint of spray material is required per acre, 11 pints would be required for each tankful.

(2) Catch the discharge from one nozzle in a pint jar as the sprayer is being operated at the speed and pressure that will be used for spraying. Measure the distance, in feet, traveled while collecting 1 pint. Then determine the rate of application per acre from Table 17.

TABLE 17
Calibration of Sprayer by Collecting the Discharge from 1 Nozzle

Distance traveled to collect 1 pint	Gallons to be applied per acre when discharge equals 1 pint and nozzles are spaced at intervals of—			
	20 inches	18 inches	15 inches	12 inches
Feet	Gallons	Gallons	Gallons	Gallons
40	82	91	109	136
50	65	73	87	110
60	54	60	73	91
70	47	52	62	80
80	41	45	55	68
90	36	40	49	62
100	33	36	44	55
110	30	33	40	50
120	27	30	37	46
130	25	28	34	42
140	23	26	31	39
150	22	24	29	36
160	20	22	28	34
180	18	20	24	31
200	17	18	22	28
220	15	16	20	25
240	14	15	18	23
260	13	14	17	21
280	12	13	16	20
300	11	12	15	18
400	5	6	7	9

EXAMPLE: If it takes 120 feet to collect 1 pint of spray and the nozzle spacing on the boom is 20 inches, 27 gallons per acre would be required (Table 17).

(3) A variation of method 2 is to measure the time required to collect nozzle discharge. Partially fill the tank with water, turn on the sprayer and set to the desired pressure.

Catch the total amount of spray discharged in a given number of minutes. Divide the number of gallons by the number of minutes. This equals the output in gallons per minute. It may be more convenient to weigh than to measure the water collected. A gallon of water weighs 8.34 pounds.

Calculate the speed of travel as follows:

$$\frac{495 \times \text{gallons per minute}}{\text{gallons per acre} \times \text{spray width, in feet}} = \text{miles per hour}$$

EXAMPLE: The nozzle output is 2 gallons per minute, the volume of application desired is 50 gallons per acre, and the spray width is 3 feet.

$$\frac{495 \times 2}{50 \times 3} = 6.6 \text{ or } 7 \text{ miles per hour}$$

If the calculated speed of travel is not practical, adjust the pressure, and calculate again.

9.3.3 Power Sprayers—Boomless Type. Calculated application data rather than calibration are used for boomless sprayers. These data are available from nozzle manufacturers.

9.3.4 Aerial Sprayers. Determine the flow rate in gallons per minute as follows:

Put a measured amount of spray in the tank or fill the tank to a definite level. Instruct the pilot to turn on the spray for a timed interval (30 or 60 seconds) while flying level and straight at the speed to be used for spraying. When plane lands, drain and measure the liquid remaining in the tank or, with the plane in the location where the tank was filled, measure the amount required to refill the tank to the same level. Compute the flow rate in gallons per minute. Compute the flow rate required as follows:

$$\frac{SWD}{F = 495}$$

S = speed of plane in m.p.h.

W = width of effective swath (not total swath), in feet

D = dosage to be applied in gallons per acre

F = flow rate, in gallons per minute

$$\frac{60 \times 43,560}{5,280} = 495$$

EXAMPLE: S = 80 m.p.h.; W = 40 ft.; D = 2 gallons per acre.

$$\frac{80 \times 40 \times 2}{495} = 12.9 \text{ gal. spray required per minute.}$$

Section 10. CLEANING AND PREPARATION FOR STORAGE

10.1 CLEANING AFTER EACH USE. All spraying equipment should be cleaned after use. If the chemical is soluble in water, a thorough flushing and rinsing with water is sufficient. Equipment that has been used for phenoxy herbicides such as 2,4-D, 2,4,5-T, silvex, erbon, or MCPA is very difficult to clean. Use one of the following methods for hand sprayers or field equipment.

(1) Remove nozzles and scrub with kerosene.

(2) Ammonia rinse.

(a) Add a box of nonsudsing detergent to 30 to 40 gallons of water, run through the pump, and bypass for 5 minutes and then out through the boom.

(b) Partly fill tank with a solution of 1-percent to 2-percent household ammonia (1 to 2 quarts in 25 gallons water, or 2 teaspoons per quart water).

(c) Leave this solution in the sprayer (including hoses and boom) overnight.

(d) Rinse thoroughly with clean water.

(3) Charcoal rinse.

(a) Use at least one-third of a tank of water. For each 10 gallons of water add one-quarter pound of activated charcoal and one-eighth to one-quarter pound of laundry detergent. Agitate this mixture vigorously to distribute the charcoal through the water.

(b) Wash the equipment for 2 minutes by swirling the liquid around so that it reaches all parts of the tank. Pump some of the liquid through the hose and nozzles.

(c) Drain the tank and rinse the equipment with clean water.

10.2 PREPARATION FOR STORAGE. Scrub the sprayer with a stiff bristle brush. Coat all iron parts exposed to the chemical with a rust inhibitor or light oil. Remove nozzles, take apart, clean, and store in light oil—before using the next year, wash in kerosene or gasoline to remove oil.

Fill pump with a rust preventive.

Remove caps from the ends of booms and stand booms on end to remove sediment. Remove, clean, and reassemble filters.

If the sprayer is powered with a gas engine, drain fuel tank and carburetor, and pour a tablespoon of engine oil through a spark plug hole. Turn motor over by hand to distribute oil on cylinder walls.

If the sprayer is to be stored outside, remove rubber hoses and keep in a cool dark place.

Thoroughly clean dusters and spreaders before storage.

TABLE 18
Relation of Centigrade and Fahrenheit Scales[1]

°C.	°F.	°C.	°F.	°C.	°F.
−40	−40	0	32	40	104
−35	−31	5	41	45	113
−30	−22	10	50	50	122
−25	−13	15	59	55	131
−20	− 4	20	68	60	140
−15	5	25	77	80	176
−10	14	30	86	100	212
− 5	23	35	95		

[1] 1° C. = 1.80° F.; 1° F. = 0.56° C. To convert C. to F.: Multiply C. by 9/5 and add 32. To convert F. to C.: Subtract 32 from F. and multiply by 5/9.

APPENDIX

List of Equivalents

Linear measure

1 inch = 2.54 centimeters
1 yard = 3 feet
1 rod = 5.5 yards = 16.5 feet = 5.03 meters
1 mile = 320 rods = 1,760 yards = 5,280 feet = 1.6093 kilometers
1 kilometer = 0.621370 mile
1 meter = 39.37 inches = 1.0936 yards

Square measure

1 square foot = 144 square inches
1 square yard = 9 square feet
1 square rod = 272.25 square feet = 30.25 square yards
1 acre = 43,560 square feet = 4,840 square yards = 160 square rods = 0.404687 hectare = an area 208.7 feet square = an area 16-1/2 feet (1 rod) x 1/2 mile
1 hectare = 2.47 acres
1 square mile = 640 acres = 259 hectares

Capacity measure (cubic)

1 cubic inch = 16.387 cubic centimeters
1 cubic foot = 1,728 cubic inches = 29.922 US liquid quarts = 25.714 US dry quarts = 0.80357 US bushel = 28.316 liters
1 cubic yard = 27 cubic feet

Capacity measure (liquid)

1 level table spoon = 3 level teaspoons
1 fluid ounce = 2 table spoons = 29.57 cubic centimeters
1 cup = 8 fluid ounces = 16 tablespoons
1 pint = 2 cups = 16 fluid ounces = 473.2 cubic centimeters
1 quart = 2 pints = 32 fluid ounces = 0.9463 liter
1 gallon = 4 quarts = 128 fluid ounces = 231 cubic inches = 0.1337 cubic feet = 3.785 liters = 16 cups = 256 tablespoons
1 milliliter = almost exactly 1 cubic centimeter
1 liter = 1,000 milliliters = 1,000 cubic centimeters = 1.057 liquid quarts

Capacity measure (dry)

1 quart = 2 pints = 67.20 cubic inches = 1.1012 liters
1 bushel = 32 quarts = 4 pecks = 1.244 cubic feet = 2150.42 cubic inches = 35.238 liters
1 liter = 0.9081 dry quart = 0.028378 bushel

Weight

1 grain = 64.7989 milligrams
1 ounce (avoirdupois) = 437.5 grains = 28.3495 grams
1 pound (avoirdupois) = 16 ounces = 7,000 grains = 453.59 grams
1 ton (short) = 2,000 pounds = 907.185 kilograms
1 ton (long) = 2,240 pounds = 1.120 short tons = 1,016.047 kilograms
1 microgram = 1 gamma = 0.001 milligram
1 gram = 1,000 milligrams = 15.432 grains = 0.0353 ounce
1 kilogram = 1,000 grams = 35.27 ounces = 2.205 pounds
1 gallon water = 8.355 pounds
1 cubic foot water = 62.43 pounds
1 kilogram water = 2.2046 pounds
1 gram water = 15.432 grains = 0.0353 ounces

Rate of speed

1 mile per hour = 1.6093 kilometers per hour = 44.70 centimeters per second = 88 feet per minute

GLOSSARY

The definitions and explanations is this glossary apply to words as they are used in this handbook. Some words have more comprehensive meanings.

Acid equivalent. The theoretical yield of parent acid from an active ingredient. It is used instead of or in addition to the active ingredient for certain herbicides.

Active ingredient. The chemical compound in a product that is responsible for the herbicidal effects.

Adsorbed. Held so tightly that the herbicide is rendered inactive or only slowly effective. The principal adsorbing agents of the soil are its inorganic (clay) and organic (humus) colloids.

Aliphatic materials—Chemically, those that have an open-chain molecular structure. As herbicides, they are less toxic to plants than aromatic compounds.

Anionic surfactant—One that has a negative charge and performs best in cold water and soft water. Most wetting agents and detergents and some emulsifiers are anionic.

Annual—A plant that completes its life cycle from seed in 1 year.

API Gravity—Gravity of oils determined by the American Petroleum Institute and expressed in degrees API.

Aquatic weeds—Undesirable plants that grow in water.

Aromatic oils and solvents—Chemically, those that have unsaturated molecular structure. As herbicides, they are generally more toxic to plants than aliphatic materials.

Ballast—A strip 12 to 16 feet wide made up of coarse material or gravel on railroad roadbeds.

Basal-bark applications—Herbicide treatments applied to the stems of woody plants just above the ground.

Berm—A narrow band along a bank; along the pavement on a highway; along the ballast on a railroad.

Biennial—A plant that completes its life cycle in 2 years. The first year it produces leaves and stores food. The second year it produces fruits and seeds.

Botanical plant name—A scientific name made up of the genus and species. Sometimes the variety or subspecies is included. It is more reliable and more universal than common names.

Broadcast application—Uniform distribution of an herbicide over an entire area.

Broadleaf plants—Botanically, those classified as dicotyledons. Morphologically, those that have broad, usually compound leaves.

Carrier—The liquid or solid material added to a chemical compound to facilitate its application in the field.

Cation exchange—The exchange of positive ions (H, Ca, Mg, Na, NH_4) from clay particles for other cations. Soils are able to filter out salts in much the same way a water softener removes them. Some soils have a larger capacity than others for

doing this. Such soils can adsorb or filter out and hold large amounts of an herbicide so that it is not immediately effective. The cation exchange capacity of a soil can be learned from the state agricultural experiment station.

c.f.s.—Cubic feet of water flow per second.

Chemical name—One that indicates the chemical composition of the compound and also the structure of the molecule.

Common plant name—An English name in common use. A plant may be known by several different common names, and one common name may be used for different plants in different parts of the country. Many common names are local.

Compatible pesticides—Compounds or formulations that can be mixed and applied together without undesirably altering their separate effects.

Concentration—The amount of active ingredient or acid equivalent in a given volume of liquid or in a given weight of dry material.

Contact herbicide—One that kills primarily by contact with plant tissue rather than as a result of translocation.

Cut-surface applications—Treatments made to frills or girdles that have been made with an ax or other tool through the bark and well into the wood of woody plants.

Deciduous trees—Those that lose their leaves during winter.

Detergent—A chemical (not soap) having the ability to remove soil or grime. Household detergents can be used as surfactants in herbicide sprays.

Diluent—Any liquid or solid material that dilutes an active ingredient in the preparation of a formulation.

Dormant spray—An herbicide applied during the period after leaf-fall or death of leaves and before bud-break of deciduous trees.

Emulsifiable concentrates—Usually liquids in which the chemical is dissolved in one or more water-insoluble solvents such as oil or benzene to which an emulsifier is added.

Emulsifier—A surface active material that facilitates the suspension of one liquid in another.

Emulsion—The suspension of one liquid as minute globules in another liquid; for example, oil dispersed in water.

Escape—A plant in a treated area that has missed treatment. For example, an annual or shallow-rooted perennial that reinfests an area after the chemical has been leached below the surface; a perennial, part of whose root system is below the treated layers of soil; or a plant that was missed at the time of application.

Extruded—A process in which a powdered carrier mixed with the herbicide is moistened until it becomes plastic and then is forced or expelled as rods. These rods are dried, ground, and screened to the required screen mesh for a granular formulation. This process increases internal pore volume and surface area. The product is frequently referred to as AA in contrast to A materials, which have not been subjected to an extrusion process.

Formulation—A term used synonymously with product. It contains the herbicide in a form that can be (1) dissolved or suspended in a carrier and distributed in solution or suspension by sprayers, (2) distributed dry by dusters or spreaders, or (3) easily vaporized for fumigation.

Fortified—Herbicidal properties increased by addition of PCP and dinoseb.

g.p.m.—Gallons per minute.

Granular products—Formulations in which the chemical is impregnated on or in vermiculite, attaclay, or other suitable carriers and then formed into granules or pellets.

Grass—Botanically, any plant of the Gramineae family. Grasses are characterized by narrow leaves with parallel veins; by leaves composed of blade, sheath, and ligule; by jointed stems and fibrous roots; and by inconspicuous flowers usually arranged in spikelets.

Growth regulator—An organic substance effective in minute amounts for controlling or modifying plant processes.

Hard water—Water that contains certain minerals, usually calcium and magnesium sulfates, chlorides, or carbonates, in solution in amounts that cause a curd or precipitate instead of a lather when soap is added. Generally defined as containing 322 p.p.m. in terms of calcium carbonate. Very hard water may cause precipitates in some herbicidal sprays.

Herbaceous plant. A vascular plant that does not develop woody tissue. It dies down each year.

Herbicide. A chemical used for killing or interrupting the normal growth of plants.

h.p. Horsepower.

Intermediate species—One whose response to an herbicide is in between the response of a susceptible and a resistant species. It is severely injured or partially controlled by higher than moderate rates.

Invert emulsion—One in which oil is the continuous phase and water is dispersed in it.

Ionic surfactant—One that ionizes or dissociates in water.

Isomers—Two or more substances having the same chemical composition but different properties.

Leaching-Movement of a substance in solution downward through the soil.

$L.D._{50}$—Lethal dose for 50 percent of the animals tested, often stated in milligrams per kilogram of bodyweight.

Low-volatile ester—Chemically, an ester with a heavy molecular weight such as the butoxy-ethanol, iso-octyl, or propylene glycol butyl ether esters. Low-volatile esters do not include the methyl, ethyl, propyl, iso-propyl, butyl, amyl, and pentyl esters. Biologically, an ester that is less liable than the high-volatile esters to injure plants by vapor activity.

Nonionic surfactant. Chemically inert.

Nonselective herbicide. A chemical that is toxic to plants generally without regard to species.

Organic matter—Plant or animal remains in the soil.

Perennial—A plant that lives more than 2 years.

pH—The chemist's measure of acidity and alkalinity. It is a scale in which the figure 7 indicates neutral, figures below 7 indicate acidity, and figures above 7 indicate an alkaline reaction.

Photosynthesis—The process by which carbohydrates are manufactured by the chlorophyll-bearing cell granules (chloroplasts) from carbon dioxide and water by exposure to the energy of sunlight.

Phytotoxic—Poisonous to plants.

Plow sole—Compact layer just below plow depth.

Postemergence—After emergence of specified weed or crop.

p.p.m.—Parts per million.

Preemergence—Prior to emergence of specified weed or crop.

Preplanting—Any time before the crop is planted. This may vary from one to several days depending on the chemical.

Product—The herbicide as it is sold commercially. It contains not only the active ingredients but also various solvents, cosolvents, surfactants, carriers, and other adjuvants that are designated as inert ingredients.

Proprietary mixture. One that is commercially available.

psi. Pounds per square inch.

Rate. The amount of an herbicide applied to a unit area, usually in terms of active ingredients.

Resistant species—One that is difficult to kill; the use of the herbicide is not recommended.

rpm—Revolutions per minute.

Selective herbicide—A chemical that is more toxic to some plant species than to others.

Slurry—A watery mixture or suspension of an insoluble herbicide.

Soil application-Application of herbicide made primarily to the soil surface rather than to vegetation.

Soil colloid—Extremely small particles of clay or organic matter that expose a very large surface area on which some herbicides are absorbed.

Soil sterilant—A herbicide that prevents the growth of green plants when present in the soil. Soil sterilization effects may be temporary or relatively permanent. It does not necessarily kill all life in the soil such as fungi, bacteria, and other micro-organisms.

Soil structure—Arrangement of soil particles into separate grains or granules.

Soil texture—Proportion of sand, silt, and clay in the soil; size of soil particles.

Solvent. A liquid such as water, oil, or kerosene used to dissolve other materials such as herbicides.

Species—A subdivision of a genus. A group of closely related individuals descendant from the same stock.

Spot treatment—Application of an herbicide to individual plants or small clumps of plants.

Spray drift—The movement of airborne spray particles from the intended area of application.

Spreader-sticker—A surfactant closely related to wetting agents that facilitates spreading and increases sticking of an herbicide on vegetation.

Stem-foliage application—An application of an herbicide to both stems and leaves of a plant.

Surfactant—A material that improves the emulsifying, dispersing, spreading, wetting, and other surface-modifying properties of herbicide formulations.

Susceptible species—One that can be killed with moderate rates of a herbicide.

Suspension—A system consisting of very finely divided solid particles dispersed in a liquid.

Translocated herbicide—One that is moved within the plant from the point of entry.

Vapor drift—The movement of herbicidal vapors from the area of application.

Viscosity of oil—Expressed in time (seconds) required for 60 c.c. of heated oil to flow through a Saybolt Universal Viscosimeter.

Volatile. A compound is volatile when it evaporates or vaporizes (changes from a liquid to a gas) at ordinary temperatures on exposure to the air.

Water-soluble power—A finely ground powder which will dissolve in water.

Weed—A plant growing where it is not desired.

Weed eradication—The complete elimination of all live plants, plant parts, and seeds of a weed infestation from an area.

Wettable powder—A finely ground powder plus a wetting agent to keep the particles suspended in but not floating on the water to which it is added.

Wetting Agent—A compound that when added to a spray causes the spray to contact plant surfaces more thoroughly.

WSSA—Weed Science Society of America.

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