Weed Identification and Control

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In the North Central States

by

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Iowa State University Press, *Ames*, Iowa, U.S.A.

First Edition, 1958

Second Edition, 1960

Library of Congress Catalog Card Number: 60-12686

FRONTISPIECE:

Included are: *Abutilon theophrasti* (Butterprint), *Agropyron repens* (Quackgrass), *Brassica juncea* (Indian mustard), *B. kaber* (Wild mustard), *B. nigra* (Black mustard), *Cardaria draba* (Perennial peppergrass), *Centaurea repens* (Russian knapweed), *Cirsium arvense* (Canadian thistle), *C. vulgare* (Bull thistle), *Convolvulus arvensis* (Field bindweed), *Cuscuta* sp. (Dodder), *Daucus carota* (Wild carrot), *Euphorbia esula* (Leafy spurge), *Plantago lanceolata* (Buckhorn), *Rhamnus cathartica* (Buckthorn), *Rumex acetosella* (Sheep sorrel), *R. altissimus* (Smooth dock), *R. crispus* (Sour dock), *Solanum carolinense* (Horsenettle), *Sonchus arvensis* (Perennial sowthistle), *Tribulus terrestris* (Puncture vine), *Xanthium* sp. (Cocklebur).

LITHOPRINTED IN THE UNITED STATES OF AMERICA BY
CUSHING - MALLOY, INC., ANN ARBOR, MICHIGAN, 1960

Foreword

This book has been designed specifically to help students know something about (1) the importance, behavior, and identity of important and common weeds, (2) methods for determining unknown weeds, (3) the basic principles of weed control, and (4) recent advances in herbicidal weed control as they apply to important weed problems.

Additional objectives perhaps possess broader cultural implications. The weedy and weed-associated plant species, together with the cultivated kinds, are those plants which comprise most of the total vegetational cover in many parts of this changing world. In large part, the characteristics and distinctiveness of the outdoor world are dependent upon them. An educated individual should know something about the diversity of higher plants and the principles of their classification.

The weeds which are treated herein are those well known in the north central United States. The types of control problems considered are those which have major reference to farming in the same area. However, many of the weed kinds concerned occur throughout most of the United States as well as other parts of the world. And the basic principles of weed control are similar wherever weeds are found.

The text reflects considerable emphasis on plant family characteristics. For example, there are numerous weedy species in the mustard and sunflower families. Unless one is a weed specialist, he is not apt to be familiar with them all. But if he can recognize plant families, it is possible to leaf through the pertinent diagnoses and illustrations rapidly—with a reasonable chance of finding the name of the plant in question.

The special section "Identification of Weeds From Flowers and Leaves" has been included in an effort to provide any individual a similar chance to identify weeds on his own. It consists of a series of five keys, four based on flower color and one providing for woody weeds. Technical terminology is largely eliminated. This procedure has some limitations inasmuch as ambiguity is occasionally unavoidable. Experience, however, has indicated that correct determinations can usually be made.

The illustrations in this volume, as indicated on the title page, are with few exceptions previously unpublished and represent the workmanship of Mrs. Frances Fenske. We have endeavored to provide a "new look" through the employment of drawings created specifically to emphasize important identification critera. The author is indebted to Mrs. Fenske for her skillful and devoted efforts on behalf of this undertaking. Most of the Leguminosae plates are reproduced from previous publications in the *Iowa State Journal of Science.* The artists concerned are Elsie Froeschner, Barbara Stewart, and Jackie Smith. In addition, Mrs. Froeschner has prepared the plates of *Dactylis glomerata, Hordeum jubatum*, and *Chenopodium album.*

With respect to the rapidly growing and increasingly specialized area of weed control, it has seemed desirable to emphasize broadly applicable principles and basic methods of approach. However, much of the present day activity and interest in weed control is concerned with the testing and employment of specific herbicidal procedures. Accordingly, some detailed material concerning the newer herbicides and their utilization is presented. Unfortunately, without frequent revision, it is impossible to keep any summary of weed control recommendations up to date. This is where the teacher must come in, to provide (in addition to other roles) timeliness and informative flexibility difficult of achievement in a written text.

Weeds are the common plants which, in addition to cultivated species, are encountered by all human beings—the pavement dwellers of our big cities perhaps excepted. Many weeds are interesting and attractive plants. In knowing something about weeds, one is better acquainted with the world about himself, and can more completely enjoy it.

Duane Isely

May, 1960

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1. The Nature and Importance of Weeds

WHAT IS A WEED?

IN GENERAL TERMS a weed is any plant growing where it is not wanted, particularly where man is attempting to grow something else. Corn or sweet clover may be considered weeds if they volunteer along a highway shoulder, yet they are important crop plants. Bermuda grass is a valuable lawn grass in the south, yet it is a noxious weed in cultivated fields. Whether a plant is a weed or not may depend on where it is encountered. There are, however, many plants which usually grow where they are not wanted, have no economic value, and usually interfere with the production of cultivated crops or with the welfare of livestock. These plants are nearly always considered to be weeds.

WHERE DID WEEDS COME FROM?

A hundred and fifty years ago the central United States was largely a vast expanse of grassland and, in certain areas, forests. The land was covered with a stable and relatively continuous series of vegetational communities. There was very little unoccupied or open soil. And there were very few of the plants which we now call weeds.

Before the initiation of agriculture by man (which possibly dates back not much more than 10,000 years), there was little place for weedy plant species. Weeds are essentially plants of disturbed areas — broken, open soil. Before man's agriculture, such areas probably made up only a small proportion of the earth's surface. They existed primarily along animal paths, around the encampments of early man, and along the edges of streams. Weeds were, in essence, unsuccessful plants in the struggle for existence.

Man's agriculture changed everything. It altered the face of the earth more drastically and quickly (geologically speaking) than any catastrophe of past ages. Plants (and animals) adapted to dominate the living world, abruptly found themselves on the edge of extinction. On the contrary, certain plants, previously barely able to exist, found vast new habitats opened up to them. As they spread and multiplied, those with the greatest potential genetic variability responded in the evolutionary sense by developing numerous forms and physiological races allowing them to take advantage of the many facets of the new environment. These plants were, and are, our weeds.

Weeds come from all corners of the earth. However, the preponderance of weedy species are native to the Eurasian continent. They spread over the Old World with man and his advancing agriculture. They were not present in the American hemisphere until the coming of the white man. Weeds of pre-Columbian Indian agriculture were entirely of American origin. Our present weeds are of both kinds, but with the Old World types predominating.

The above discussion points up another fact: That while weeds as well as other plants have natural means of dispersal (wind, water, birds carrying seed, etc.), man is by far the most important agency in their distribution. Man has taken them with his agricultural seed, his feeds, implements, etc., essentially to all major areas where adapted. He is still dispersing them within those areas.

Weeds are, then, one of the by-products of man's ascendency. In many parts of the world they constitute, together with cultivated plants, the principal vegetation of the land. The so-called natural plant world — and this is very true in the north central United States — is rapidly becoming a memory of the past.

IMPORTANCE OF WEEDS

Economic losses due to weeds have been said to be as great as those caused by insect injury to crops and plant diseases combined. Such losses, however, are not nearly as striking as those due to disease and insect outbreaks and are too often taken for granted.

Weeds, through their competitive effects, reduce crop yield. This perhaps is their most significant contribution to reduction of agricultural income. But weeds affect human beings and their agriculture in further ways. Control measures whereby weeds are maintained at "moderate" infestation levels cost millions of dollars every year. Crop cultivation, which constitutes a major part of farm work, is regarded as a routine operation, yet much cultivation would be unnecessary were it not for weeds. Chemical control methods, now in rapid ascendency, are, likewise, often expensive.

Aside from effects on total yield, weeds reduce the quality and value of agricultural products, e.g. hay. Weeds serve as important hosts for insect and disease pests, thereby accentuating crop losses from these sources. Certain weeds are poisonous to man and animals, cause hay fever, etc. The miscellaneous implications of weeds are manifold: they occupy industrial sites; brushy weeds interfere with rural telephone and power lines; they obstruct vision on secondary roads; they may render waste areas, roadsides, lawns, and parks unsightly.

This topic would not be complete without pointing up some of the beneficial effects of weeds. In certain areas such as abandoned farmland, waste areas, and some roadsides, "weeds" constitute the only major vegetation. Their value in preventing wind and water erosion and in serving as pioneer plants until a more permanent vegetation develops is not generally appreciated. Weeds furnish cover and food for wildlife. Some are excellent sources of honey. Many are highly attractive plants, and, in non-agricultural areas, along with wild flowers and trees, contribute much to the variety and attractiveness of the outdoors.

In some of the above situations, although the plants involved may be weedy species, they cannot properly be considered weeds. In such roles, these species are desirable or beneficial plants and should be recognized as such.

CHARACTERISTICS OF WEEDS

The prime characteristic possessed by all important weeds is their ability to thrive in land subject to the plow. This characteristic is one not possessed by the majority of plant species. For example, once the prairie vegetation of the central United States was turned over, most of the plants never came back. Many weeds, it is true, will disappear under conditions of continuous cultivation, but if this cultivation is halted for a few years they will reinvade the site (or emerge from seeds already in the soil). This, most non-weedy species cannot do.

Weeds in general usually possess a number of specific attributes which render their success in disturbed areas possible and contribute to their ability to persist in spite of man's efforts to the contrary. Some of these are:

Perennial Underground Roots or Stems

Weeds possessing these structures will persist from year to year even though seed production is prevented. The underground parts of some weeds will spread rapidly in all directions, sending up aerial stem buds at regular intervals. Such weeds may not only persist, but their spread will actually be favored by cultivation. For instance, small fragments of the creeping roots of Canadian thistle *(Cirsium)* are capable of initiating new plants. Cultivation procedures may spread pieces of roots from a limited patch over much of a field, thus greatly augmenting the infestation.

Abundant Seed Production

Many weeds are capable of producing literally thousands of seeds. Examples: pigweed *(Amaranthus)*; tumble mustard *(Sisymbrium)*.

Seeds Very Long-Lived

Seeds of many weeds may retain their viability in the soil for 10-50 years. Weeds of this type include butterprint *(Abutilon)*; purslane *(Portulaca)*; pigweed *(Amaranthus)*; dock *(Rumex)*; evening primrose *(Oenothera)*.

Rapid Growth

Weeds are frequently capable of growing to maturity and setting seed within a very short period of time (30-60 days). Commonly, seeds are formed before adequate control measures can be taken. Examples: foxtail *(Setaria)*; pigweed *(Amaranthus)*.

Competitive Ability

Many weeds can overtake and retard crop plants even though the latter have had a head start. Thus they are often successful in outcompeting crops for light. Futhermore, studies have shown that certain weeds have requirements for mineral nutrients and water which considerably exceed those of many cultivated plants.

Unpalatability to Livestock

Frequently weeds which are successful in pastures are distasteful or poisonous to animals, or are protected by spines or similar structures. They are thus free to reproduce and spread unimpeded by normal grazing. Examples: bull thistle *(Cirsium)*; mullein *(Verbascum)*.

GROWTH HABITS OF WEEDS

The above-ground parts of weeds may be woody or herbaceous. Woody plants are perennials; the stems as well as the roots live from season to season. The tops of herbaceous plants (whether annual or perennial), on the other hand, die each year and do not develop woody tissues. The majority of plants ordinarily considered weeds are herbs.

Weeds may be erect, prostrate, or grow with a vine-like habit. Ordinarily the stem bears leaves, but in a few (e.g. dandelion, *Taraxacum*; plantain, *Plantago*), the leaves are all in a cluster at ground level.

The growth habits and reproduction of herbaceous weeds is closely correlated with their duration. Annuals complete their life cycle within a single growing season. They germinate in the spring or summer, produce seed, and die the same year. The seeds of winter annuals germinate in the fall of one growing season, live over winter, produce seed, and die the next spring. Some species may behave either as annuals or winter annuals. Biennials live two years. Usually they develop only a basal cluster (rosette) of leaves and an overwintering storage root the first season. A leafy stem, flowers, and seed emerge the second season. The plant then dies. Perennials are capable of living more or less indefinitely. The tops die back each year, but underground structures, stems or roots, live over the winter. New stems and leaves then develop the subsequent season.

2. Weed and Agricultural Seed Laws

THERE ARE two kinds of state laws which deal with weeds: weed laws and agricultural seed laws. The former is concerned with the eradication of existing stands of weeds, the latter with the spread of weeds through agricultural seeds.

These laws deal primarily with specified noxious weeds. It is often said that these are the worst weeds, but more precisely they are usually those which, once established, are notoriously difficult to eradicate. The majority are perennials which are spread by underground roots or stems and which cannot be controlled by ordinary cultivation methods. Some highly competitive annuals, capable of producing numerous, long-lived seeds, are also considered to be noxious.

AGRICULTURAL SEED LAWS

All 48 states in the United States possess agricultural seed laws, and there is also a Federal Seed Act which is concerned with the movement of seed in interstate commerce. Seed laws are concerned with the proper labeling of seed stocks offered for sale and in preventing the sale and distribution of seed injurious to agriculture.

The presence of weed seeds in agricultural seed is one of the major factors affecting seed quality, and the provisions relating to weeds and weed seeds constitute important portions of these laws. For example, the total percentage by weight of weed seeds must be given on the seed analysis label. If this percentage exceeds a certain amount (1-3 per cent in most states) it is illegal to sell the seed. In addition, legislation is directed towards designated, noxious weeds. Treatment and terminology vary from state to state; usually two or all three of the following categories are included: (1) Prohibited (or primary noxious). Sale of seed containing any seeds of the specified noxious weeds is prohibited. (2) Restricted. Sale of seed is prohibited if the number of seeds of any of the specified kinds exceeds a certain rate of occurrence (e.g. 25 per pound). If the weed seed kind (or kinds) is present in lesser amounts, the seed may be sold if the name of the weed and the rate of occurrence is properly indicated on the label. (3) Secondary noxious. There are no restrictions on sale (must comply with requirements relating to total percentage by weight) if the weed seed and its rate of occurrence is labeled.

In general, the species considered primary noxious or prohibited are perennials with creeping roots or stems. On the other hand, secondary noxious kinds include annuals and biennials as well.

The More Important Noxious Weeds of the North Central States[1]

Agropyron repens	Quackgrass
Agrostemma githago	Corn cockle
Allium vineale	Wild garlic
Allium canadense	Wild onion
Brassica spp.	Mustards
Cardaria draba	Perennial peppergrass
Centaurea repens	Russian knapweed
Chrysanthemum leucanthemum	Oxeye daisy
Cirsium arvense	Canadian thistle
Convolvulus arvensis	Field bindweed
Convolvulus sepium	Hedge bindweed
Cuscuta spp.	Dodder
Daucus carota	Wild carrot
Euphorbia esula	Leafy spurge
Plantago lanceolata	Buckhorn
Rumex acetosella	Sheep sorrel
Rumex spp.	Dock
Solanum carolinense	Horsenettle
Sonchus arvensis	Perennial sowthistle
Sorghum halepense	Johnson grass
Thlaspi arvense	Pennycress

Most of the seed laws in the North Central States receive at least reasonable enforcement and some have outstanding programs. The majority of reputable seed houses properly label their stocks and do not attempt the sale of seed illegal under the law. However, most of these laws apply primarily to seed dealers and have little jurisdiction over farm-to-farm sales. Some, it is true, have farm sales provisions but these are, for the most part, poorly enforced. Since little of the seed of certain crop kinds (e.g. oats and red clover) ever goes through dealer hands, this would seem to be a major weakness in the over-all effectiveness of seed laws. Seeder box surveys have indicated a high proportion of planted seed to be polluted with noxious weed seeds.

WEED LAWS

The majority of the North Central States have weed laws or statutes pertaining to the eradication of noxious weeds. These laws vary

[1]Noxious in three or more states in agricultural seed laws.

considerably in content, and the degree to which their provisions are carried out is diverse. A few of the states do not have weed laws.

In general, the Secretary or Commissioner of Agriculture is the government official responsible for over-all weed law enforcement. Local enforcement is usually carried out by the county board of supervisors or commissioners whose jurisdiction is described in the law. Ordinarily this board has the authority to appoint a county weed officer (weed commissioner, supervisor, or inspector). In some states the local administrative unit is a weed control "district" which is set up after a proper petition by a certain proportion of the landowners or taxpayers. Some laws designate certain municipal officials (e.g. the mayor) as weed inspector for his municipality.

The activities of the county weed commissioner (or his equivalent) in broad terms relate to keeping up with the weed problem in his area, locating stands of noxious weeds, and overseeing their eradication. Ordinarily control or eradication measures are recommended to the landowner who will then, presumably, carry them out. If cooperation is not forthcoming, the weed commissioner has the authority to order the weeds destroyed at county expense, the cost subsequently being charged back to the owner of the land through his taxes. Some county weed commissioners perform considerable community service beyond their responsibilities under the law; they may act in an advisory capacity in all matters relating to weed control and cooperate with extension and other personnel in setting up educational and action programs.

The weed kinds most frequently declared noxious in the North Central States' weed laws include bindweed (*Convolvulus arvensis*), leafy spurge *(Euphorbia esula)*, and Canadian thistle *(Cirsium arvense)*. The state of Minnesota has recently deleted lists of noxious weeds from its law, in effect declaring all weeds noxious. ". . .any weed that is injurious to public health, public roads, crops, livestock and other property may be ordered destroyed by a weed inspector."

The degree to which the provisions of weed laws are actually put into practice is varied. Some states (e.g. Minnesota) have state-wide, well administered and aggressive programs. In others the number of counties appointing weed commissioners or setting up weed control districts is not large; thus the programs are scarcely state-wide. Much obviously depends upon the weed commissioner himself and the nature of his appointment. Some county programs are less than active. In most instances the commissioner acts primarily in an advisory capacity and rarely invokes the provisions of the law.

3. Distribution and Occurrence of Weeds

IT IS widely held by laymen and professional men alike that weeds, unlike other plants, are capable of growing practically anywhere; if certain weeds do not occur in a specific region, state, or country, it is because they have not yet been introduced there. Some weeds (e.g. crabgrass) are indeed so tolerant of varying climatic and local ecological conditions as to lend considerable credulence to this belief. But it is not correct. Weeds are like other plants. Each kind will succeed only within a certain range of environmental conditions. For some kinds of weeds this range is narrow or restricted; for others it is exceedingly broad.

Weeds and other wild species have natural means of distributing themselves: wind, water, seeds passed through digestive tracts of animals, etc. Man is an additional distributional and most important agent for those plants which grow in agricultural areas. In his agricultural seed, feeds, with his implements, etc., he has distributed seeds of weeds to all areas of the world. Those weeds which have become established in specific regions are those which are adapted. The ability to grow and reproduce under particular environmental conditions is the basic factor underlying the distribution and occurrence of weeds.

The above concerns the occurrence of weeds on a regional rather than a local basis. Weeds may be absent from limited areas, e.g. specific farms, either because (1) they have not yet been introduced to the area involved, or have been introduced and successfully eradicated, or (2) because they are not adapted to grow there.

Also, the above does not deny that new weeds still occasionally show up in the United States, or that weeds new to certain states are intermittently reported. But these are exceptions to the general rule. Furthermore, many "new" weeds are not new. Some, limited in distribution, have doubtless been present many years before their discovery. Some are merely waifs, species sporadically reported which are too poorly adapted to reproduce and maintain themselves. Other so-called new weeds represent a plant response to changed environmental conditions. For example, it has been alleged that numerous weeds, not previously known, have invaded many of the western ranges. Most of the species involved had been around for many years but occupied relatively limited habitats and were not frequently observed. With the weakening and destruction of the native grass stands due to continued overgrazing, vast areas were opened up into which the weeds spread and multiplied.

REGIONAL DISTRIBUTION OF WEEDS

Regions of the world which have similar climates and in which similar crops are grown usually possess many weed kinds in common. The weeds of the central and eastern United States are much the same as those in temperate western Europe. Many Mediterranean weeds do well in California. Tropical agricultural areas possess similarities in their weed floras. But within these gross areas of adaptation we are woefully short of information concerning the distributional and environmental vagaries of specific weeds.

American botanists have studied the distribution and to a lesser degree the climatic requirements of many native wild plants and trees. For many of these the distributional limits are so well known that they can be drawn rather accurately on a map. The possibility of occurrence in a given county or town can often be indicated. This can be done for very few weeds; the prejudice that weeds can grow anywhere seems to have discouraged pertinent studies. For example, we know that Canadian thistle *(Cirsium)* and quackgrass *(Agropyron)* are weeds of more temperate and humid climates, but we can, in no way, indicate their precise distributional tolerance. Neither do we know exactly why Canadian thistle, for example, will not thrive in the South. On the other hand, Bermuda grass *(Cynodon)* and Johnson grass *(Sorghum)* are southern weeds. They do not extend North because the overwintering rootstocks are killed by low winter temperature. But the critical temperatures are not known nor are other factors which may limit the occurrence of these plants; likewise, their actual total range in the United States can only be estimated. Our knowledge of the distributional peculiarities of most weeds is in a similarly generalized stage.

Many weeds are able to tolerate a rather wide range of climatic life zones to the extent that they can live and reproduce. This does not mean that they are equally adapted to all of these diverse climatic conditions. They may do best only under rather specific growing conditions; contrariwise, a given species may possess a number of physiologically different strains which may fairly well adapt it to several climatic or soil provinces. In any case, weeds (and most other plants) occur not only in areas to which best fitted, but extend beyond with a decreasing degree of success in the struggle for existence, until limits of their various tolerances are reached.

These facts are borne out if the behavior of weeds as agricultural pests is considered. Most major weedy species possess economic significance within only a portion of their total range. Beyond this, they may be reasonably common but are less apt to assume a dominant role in the vegetation of disturbed areas; still further, their occurrence becomes sporadic, or their populations will succeed only in favorable seasons. Quackgrass and Canadian thistle occur throughout Iowa, but their impact on crop production is much greater in the northern part of that state and continues to increase as one proceeds north into Minnesota and Wisconsin. Similarly, horsenettle *(Solanum)* may be found throughout the state of Iowa but is of much greater significance in the sourthern portion; it is increasingly prevalent and aggressive in Missouri.

Weeds compete not only with crop plants but with each other. A weed growing under conditions to which best adapted, both from the standpoint of vegetative growth and reproduction, will fare better in the competitive struggle with other plants (weeds or crops) than one growing where climatic and other conditions are less than optimum. In the latter circumstance it will probably assume a subordinate role in the vegetational spectrum, will interfere less with the growth of crop plants and other weeds, and will be more easily amenable to control measures.

The above generalizations are largely well known, but specific data are almost completely lacking. It is not possible to estimate the economically significant portion of the range of a weed species without such data; hence, we have no valid estimates.

This type of information, were it available, would be useful in a wide variety of manners. A single example: It could do much to render agricultural seed and weed laws more realistic. Many laws designate as noxious, or prohibit, weeds rarely found in their states, but which are presumed to represent potential threats if introduced. For instance, Russian knapweed *(Centaurea)* and perennial peppergrass *(Cardaria)* are typically weeds of arid regions. They are prevalent and important primarily from the drier portions of the high plains westward. Contrariwise, they are of relatively rare occurrence in the more humid central and eastern parts of the country. However, they are designated as primary noxious in many of the central and eastern states; it is illegal to offer for sale agricultural seed containing their seeds. It has been suggested that the reason Russian knapweed and perennial peppergrass have not become widely distributed in the remainder of the country is the existence of these seed laws.

It is not the purpose of this discussion to criticize agricultural seed or weed laws. For the most part they have been put together from the best information at hand, and any measure which will limit the further spread of potential weed pests is to be commended. Seed laws have done much within states to retard or prevent the infestation of yet more land with locally adapted major weed species. But the thesis that these laws have been the controlling factor in relegating important weeds to specific parts of the country is probably fallacious. Russian knapweed is common in the western part of the country because this is where it is capable of thriving. It has been introduced in many parts of the United States (despite seed laws). Local stands may or may not persist and usually show little tendency to spread. There is, however, little precise data as to the climatic or geographic limits of Russian knapweed or other noxious weeds.

It is not illogical to take a conservative position and consider such plants as at least potentially noxious until such data is forthcoming. This agricultural seed laws have done. Organized information regarding the range of adaptability of major weeds could, however, help render legal statutes realistic and perhaps make it possible for control officials to better channel their efforts.

The above topic was introduced as an example. It is but one of the ways in which progress in the total area of weed control could be facilitated — if we know more about the plants concerned.

THE OCCURRENCE OF WEEDS AS AFFECTED BY HABITAT

Every layman who has been harassed by dandelions in his yard has had the opportunity to note that dandelions rarely occur in cornfields. Likewise, the typical weeds of pastures are rarely found in soybean fields and vice versa. To what extent do habitat and cropping practices control or modify the nature of weed populations?

As emphasized above, weed species are most successful in situations to which they are best adapted to grow and reproduce, and which give them a competitive advantage over other kinds. In crops there is a tendency for weeds which have a life cycle similar to that of the cultivated plant to make out best. If the weed matures seed at the same time as the crop and this seed is subsequently harvested and replanted with agricultural seed, success of the weedy species is further guaranteed. For example, many of the major weeds of fall-planted cereals are winter annuals; of spring grains, summer annuals. Ordinarily, perennial weeds which can tolerate cutting are most persistent in stands of alfalfa. Lawn weeds are low-growing species which are not destroyed by mowing, etc.

In the past, when the same crop was frequently grown on a given piece of ground, season after season, the weed flora of each agricultural crop kind was rather distinctive. Favored weedy species gradually became more and more prevalent each succeeding year. With ascendency of the practice of crop rotation, much of this individuality of weed populations disappeared. Many pests, formerly of major importance in specific agricultural areas, became relegated to secondary roles; crop rotation through the simple expedient of shifting the habitat is one of the most effective means of weed control.

Differences between the weeds in corn, small grains, and legumes still exist, it is true, but these differences are largely matters of degree. Most of the same weeds occur in all of these crops, but some, depending upon the crop kind, enjoy a greater measure of success than others and become more prominent. But there is little opportunity for a year-to-year build-up.

The recent upsurge in the use of herbicides has further modified the nature of weed populations. 2,4-D, tending to kill a large proportion of the dicotyledonous broad-leaved weeds, has resulted in increased prevalence and importance of many grassy species. The more recent introduction of weed-killing chemicals effective on annual grasses may reverse this trend.

There is, in general, a greater discrepancy between the weed species of non-tilled areas (permanent pastures and range) and rotation farmland, than between various phases of an ordinary rotation. For example, successful weeds of permanent pastures, vervains *(Verbena)*, biennial thistles *(Cirsium)*, ironweeds *(Vernonia)*, buckbrush *(Symphoricarpos)*, *et al.* are infrequently found in land subject to cultivation. On the other hand, the common weeds of corn, (foxtail grass, *Setaria*; butterprint, *Abutilon*; pigweeds, *Amaranthus*) are not usually seen in permanent pastures. Weeds of roadsides, fence rows, and untended areas include a hodge-podge of species, both of cultivated and permanent pasture land, as well as additional kinds usually not characteristic of either. These latter habitats possibly exhibit a greater diversity of weedy forms than any strictly agricultural areas.

There are many factors which influence the habitat characteristics of weeds other than man's cropping practices. These include the nature of the soil, local climate, methods and effectiveness of spread from place to place, ability to reproduce successfully, and competitive ability with associated weeds and other plants. Some weeds, as indicated in the section above, have a much wider tolerance to a variety of environmental conditions than others. The multiplicity of factors which may influence the occurrence and prevalence of weeds results in many inconsistencies if an attempt is made to interpret them on a crop basis, and to some extent defeats such a classification. For example, a given weed may in one area largely be associated with one crop, but in another with an entirely different biotic situation. Some weeds are overwhelmingly abundant in certain limited regions but are almost entirely absent for miles around. Why? We can hazard guesses as to the ecological and distributional peculiarities of weeds, but we know very few direct answers for specific kinds. Much weed control planning could be placed upon a more scientific basis if the environmental tolerances of these plants were better understood.

AGRICULTURAL AREAS AND ASSOCIATED WEEDS

The following enumerates "typical" weeds of various agricultural and related areas of the north-central states. The association of any weed with a specific habitat or crop kind is subject to some of the limitations discussed above. The characteristic weeds of a given situation may be quite different in various parts of the North Central States. For instance, the weedy inhabitants of permanent pastures in Indiana are largely at variance with those of the ranges in western South Dakota. Many weeds are of considerable local importance, but their occurrence is sporadic. Others are limited to specific portions of our range. In some instances the difference between weed populations in different habitats is not so much a matter of different kinds, but the relative preponderance and the degree of dominance assumed by various species.

Hence, the following is intended to provide only a general picture of the association of weed kinds with particular agricultural areas and to further emphasize the importance of man's manipulations upon the nature of weed populations. It does not constitute a check list applicable in any one agricultural section. Obviously, also, no attempt has been made to list all weed kinds for any area.

Corn

Annuals - Barnyard grass *(Echinochloa crusgalli)*; Butterprint *(Abutilon theophrasti)*; Cocklebur (*Xanthium* spp.); Crabgrass (*Digitaria* spp.); Foxtail grasses (*Setaria* spp.); Pigweeds (*Amaranthus* spp.); Shoo-fly *(Hibiscus trionum)*; Smartweeds (*Polygonum* spp.); Witchgrass *(Panicum capillare)*.

Perennials - Canadian thistle *(Cirsium arvense)*; Field bindweed *(Convolvulus arvensis)*; Horsenettle *(Solanum carolinense)*; Quackgrass *(Agropyron repens)*.

Soybeans

Annuals - Barnyard grass *(Echinochloa crusgalli)*; Butterprint *(Abutilon theophrasti)*; Foxtail grasses (*Setaria* spp.); Pigweeds (*Amaranthus* spp.); Shoo-fly *(Hibiscus trionum)*; Smartweeds (*Polygonum* spp.); Witchgrass *(Panicum capillare)*.

Perennials - Canadian thistle (*Cirsium arvense*); Horsenettle (*Solanum carolinense)*; Quackgrass *(Agropyron repens)*.

Small Grains

Annuals - Cocklebur (in stubble) (*Xanthium* spp.); Common ragweed (in stubble) *(Ambrosia elatios)*; Corn cockle (southern) *(Agrostemma githago)*; Field peppergrass *(Lepidium campestre)*; Mustards (*Brassica* spp.); Pennycress *(Thlaspi arvense)*; Wild buckwheat *(Polygonum convolvulus)*; Wild oats (northwestern only) *(Avena fatua)*.

Perennials - Canadian thistle (*Cirsium arvense*); Common milkweed *(Asclepias syriaca)*; Docks (*Rumex* spp.); Field bindweed *(Convolvulus arvensis)*; Horsenettle *(Solanum carolinense)*; Johnson grass (southern) *(Sorghum halepense)*; Perennial sowthistle *(Sonchus arvensis)*; Quackgrass *(Agropyron repens)*.

Legumes and Forage Grasses

Annuals - Annual spurges (*Euphorbia* spp.); Barnyard grass (*Echinochloa crusgalli*); Common peppergrass (*Lepidium densiflorum*); Common ragweed (*Ambrosia elatior*); Dodder (legumes only) (*Cuscuta* spp.); Foxtail grasses (*Setaria* spp.); Ground cherry (*Physalis* spp.); Japanese brome (*Bromus japonicus*); Kochia (*Kochia scoparia*); Lambsquarter (*Chenopodium album*); Pennycress (*Thlaspi arvense*); Smartweeds (*Polygonum* spp.); Witchgrass (*Panicum capillare*).

Perennials - Canadian thistle (*Cirsium arvense*); Docks (*Rumex* spp.); Field bindweed (*Convolvulus arvensis*); Ground cherry (*Physalis* spp.); Horsenettle (*Solanum carolinense*); Plantains (*Plantago* spp.); Quackgrass (*Agropyron repens*); Sheep sorrel (*Rumex acetosella*); Yarrow (*Achillea millefolium*); Yellow rocket (*Barbarea vulgaris*).

Permanent Pastures

Annuals - Downy bromegrass (*Bromus tectorum*); Hedge mustard (*Sisymbrium officinale*); Horseweed (*Erigeron canadensis*); Ragweed (*Ambrosia* spp.); Stickseed (*Lappula echinata*).

Biennials - Biennial thistles (*Cirsium* spp.); Evening primrose (*Oenothera biennis*); Mullein (*Verbascum thapsus*); Wild carrot (*Daucus carota*).

Perennials - Bonesets (*Eupatorium* spp.); Buckbrush (*Symphoricarpos* spp.); Canadian thistle (*Cirsium arvense*); Dandelion (*Taraxacum officinale*); Ironweed (*Vernonia* spp.); Sheep sorrel (*Rumex acetosella*); Squirrel-tail grass (*Hordeum jubatum*); Vervains (*Verbena* spp.); Whorled milkweed (*Asclepias verticillata*); Yarrow (*Achillea millefolium*).

Lawns

Annuals - Chickweed (*Stellaria media*); Crabgrass (*Digitaria* spp.); Knotweed (*Polygonum aviculare*); Nimblewill (*Muhlenbergia schreberi*); Prostrate vervain (*Verbena bracteata*); Speedwells (*Veronica* spp.).

Perennials - Coarse-leaved fescues (*Festuca* spp.); Dandelion (*Taraxacum officinale*); Plantains (*Plantago* spp.); Quackgrass (*Agropyron repens*); Self-heal (*Prunella vulgaris*).

Home Gardens

Annuals - Annual spurges (*Euphorbia* spp.); Black nightshade (*Solanum nigrum*); Common ragweed (*Ambrosia elatior*); Crabgrass (*Digitaria* spp.); Foxtail grasses (*Setaria* spp.); Lovegrass (*Eragrostis* spp.); Pigweeds (*Amaranthus* spp.); Prickly lettuce (*Lactuca scariola*);

Purslane *(Portulaca oleracea)*; Shepherd's purse *(Capsella bursa-pastoris)*; Smartweeds (*Polygonum* spp.); Witchgrass *(Panicum capillare)*; Yellow sorrel *(Oxalis stricta)*.

Perennials - Field bindweed *(Convolvulus arvensis)*; Quackgrass *(Agropyron repens)*.

Roadsides, Fence Rows, Waste Areas

Annuals - Annual spurges (*Euphorbia* spp.); Downy bromegrass *(Bromus tectorum)*; Horseweed *(Erigeron canadensis)*; Japanese brome *(Bromus japonicus)*; Kochia *(Kochia scoparia)*; Peppergrass (*Lepidium* spp.); Pennycress *(Thlaspi arvense)*; Prickly lettuce *(Lactuca scariola)*; Ragweeds (*Ambrosia* spp.); Spanish needles (*Bidens* spp.); Sunflowers (*Helianthus* spp.); Wild hemp *(Cannabis sativa)*.

Biennials - Goatsbeard *(Tragopogon pratensis)*; Wild carrot *(Daucus carota)*.

Perennials - Asters (*Aster* spp.); Catnip *(Nepeta cataria)*; Chicory *(Cichorium intybus)*; Common milkweed *(Asclepias syriaca)*; Docks (*Rumex* spp.); Goldenrod (*Solidago* spp.); Ground cherry (*Physalis* spp.); Hedge bindweed *(Convolvulus sepium)*; Horsenettle *(Solanum carolinense)*; Johnson grass (southern) *(Sorghum halepense)*; Poison ivy *(Rhus toxicodendron)*; Quackgrass *(Agropyron repens)*; Squirrel-tail grass *(Hordeum jubatum)*; Sunflowers (*Helianthus* spp.); White cockle *(Lychnis alba)*; Wild rose *(Rosa arkansana)*; Yellow rocket *(Barbarea vulgaris)*.

Around Farm Buildings, Feed Lots, etc.

Annuals - Barnyard grass *(Echinochloa crusgalli)*; Buffalo bur *(Solanum rostratum)*; Cocklebur (*Xanthium* spp.); Fall panicum *(Panicum dichotomiflorum)*; Jimson weed (southern) *(Datura stramonium)*; Kochia *(Kochia scoparia)*; Mayweed *(Anthemis cotula)*; Prickly lettuce *(Lactuca scariola)*; Round-leaved mallow *(Malva neglecta)*.

Perennials - Hedge bindweed *(Convolvulus sepium)*; Plantains (*Plantago* spp.); Quackgrass *(Agropyron repens)*.

Paths, Dry Trampled Ground, Neglected Corners in Urban Areas

Annuals - Crabgrass (*Digitaria* spp.); Common ragweed *(Ambrosia elatior)*; Foxtail grasses (*Setaria* spp.); Lovegrass (*Eragrostis* spp.); Knotweed *(Polygonum aviculare)*; Prickly lettuce *(Lactuca scariola)*; Prostrate spurge *(Euphorbia maculata)*; Prostrate vervain *(Verbena bracteata)*; Sandbur *(Cenchrus pauciflorus)*; Shepherd's purse *(Capsella bursa-pastoris)*.

Perennials - Dandelion *(Taraxacum officinale)*; Docks (*Rumex* spp.); Pathrush *(Juncus tenuis)*.

4. Scientific Names and Technical Terms

THE GREATEST BARRIER to an understanding of any specialized area of knowledge on the part of the general public is unfamiliarity with the terminology. The student approaching such an area immediately finds himself faced with the necessity of learning at least some of this terminology.

The only words in the English language which are not technical to some degree are those which relate to objects and experiences which all human beings contact or share in. All other areas of endeavor possess technical terminology, e.g. words not generally employed in common parlance. Such words are a necessity: nouns for names of things, adjectives and adverbs to describe conditions, and special terms or combinations thereof to communicate concepts. The automobile mechanic, the radio ham, the stamp collector each has his special vocabulary. It should not be strange then, that we need names for plants and terms descriptive of their parts and functions.

SCIENTIFIC NAMES

The use of scientific names is much more exact and less likely to lead to confusion than that of common names. Common names are exceedingly provincial, and their usage is varied in different parts of the country. The same plant may have numerous common names, or a given common name may be employed to refer to a variety of plants.

Let us consider but a single example: some of the various common names applied to the weed *Erigeron canadensis*, i.e. Whitetop, Fleabane, Horseweed, Bitterweed, Hogweed, Mare's-tail, and Blood stanch. The name Whitetop is also used to refer to a perennial noxious weed, *Cardaria draba*, which is also called Perennial peppergrass or Hoary cress. Horseweed also refers to several other plants, most commonly *Ambrosia trifida*, otherwise Great ragweed, Giant ragweed, or Bloodweed. Bitterweed may mean any of several plants in addition to *Erigeron canadensis*, commonly referring to certain species of *Helenium*, which are also designated Sneezeweeds. Hogweed may mean any of half a dozen kinds of plants; it is frequently applied to *Anthemis cotula*, which is also known as Dog fennel, Mayweed, Stinkweed, or Chamomile.

Only the more common and conspicuous plants possess common names. Scientific names are not more difficult than common names. They are merely names which many of us are not used to. Dahlia, Gladiolus, and Lespedeza are scientific names which have been adopted into common usage.

It must be admitted that scientific names have certain limitations. They cannot be used when talking to the general public. Futhermore, they are sometimes subject to change as our knowledge of plant classification increases.

CLASSIFICATION OF PLANTS AND FORMATION OF SCIENTIFIC NAMES

Every recognizable kind of a plant that ordinarily does not interbreed with other kinds is termed a species. Similar species are grouped together in genera (singular, *genus*). Scientific names consist of the generic and specific names written together, the generic name first, capitalized, the specific name following in small letters. The weeds yellow foxtail and green foxtail are both members of the genus *Setaria*. The scientific name of yellow foxtail is *Setaria lutescens*; that of green foxtail is *Setaria viridis*. Both plants have the same generic name but different specific ones.

Similar genera are grouped together into plant families. *Setaria* belongs to the grass family or Gramineae. Red clover, *Trifolium pratense*, belongs to the pea family, the Leguminosae. The flowering plants existent in the world include about 300 families.

TECHNICAL TERMS

The employment of technical terms in this book will be held to a reasonable minimum. Many of those which are essential should already be familiar to the student. They are reviewed in the following chapter.

The necessity of terms to obtain precision of expression and as a means of referring to plant parts was discussed above. It is impossible to read botanical material intelligently without knowing some terminology. Sometimes students avoid the use of such words in their own attempts at communication and resort instead to cumbersome descriptive phrases. Mark Twain did just this in his description of the process of harnessing a team of horses, quoted below.

"The man stands up the horses on each side of the thing that projects from the front end of the wagon, and then throws the tangled mass of gear on top of the horses, and passes the thing that goes forward through a ring, and hauls it aft, and passes the other thing through the other ring and hauls it aft on the other side of the other horse opposite to the first one, after crossing them and bringing the loose end back, and then buckles the other thing underneath the horse and takes another thing and wraps it around the thing I spoke of before, and puts another thing over each horse's head, with broad flappers to keep the dust out of his eyes, and puts the iron thing in his mouth for him to grit his teeth on, uphill, and brings the ends of these things aft over his back, after buckling another one around under his neck to hold his head up, and hitching another thing on a thing that goes over his shoulder to keep his head up when he is climbing a hill, and then takes the slack of the thing which I mentioned a while ago, and fetches it aft and makes it fast to the thing that pulls the wagon, and hands the other things up to the driver to steer with." Mark Twain. A Tramp Abroad, Vol. II. 19-20.

5. External Plant Structure and Common Terms Employed

PLANTS DEVELOP from seeds, or from overwintering stems or roots as described below. The seed is a structure containing an inactive embryonic plant and stored food used by the plant in initiating growth. Under favorable conditions the seed germinates and the young plant sends out a root, stem, and leaves. The first leaflike structures present above ground on the seedlings of most broad-leaved plants are cotyledons. The root, stem, and leaves make up the vegetative structures of the plant. After a period of growth (a month to several years) the plant develops reproductive structures. These include the flower, fruit, and seed.

VEGETATIVE STRUCTURES

The Root

Roots may be annual or perennial. They may have one main axis, a taproot, with much smaller secondary branches, or they may be much branched, e.g. fibrous roots of grasses. Taproots or root crowns are frequently thickened and serve as food storage organs or as overwintering perennial structures which will send out new shoots the following year. Horizontally developing perennial underground roots are possessed by many noxious weeds. These roots send out stem buds at intervals. Small fragments of such roots are frequently capable of developing new plants.

The Stem

Stems may be subterranean or aerial. Underground stems are usually, at least in part, perennial. They frequently form overwintering crowns or special storage organs (tubers, bulbs). Certain noxious weeds (e.g. quackgrass) possess horizontally elongated underground stems known as rootstocks or rhizomes. These structures function in much the same way as creeping underground roots, are perennial, and are capable of producing aerial stems and root systems.

Above ground stems may be perennial or annual. Those of trees and shrubs are perennial and soon become woody. Those of most weeds and crop plants are annual; that is, they die back to the ground every year even if underground stems or roots are perennial in nature. Annual stems ordinarily do not become woody but are soft or herbaceous. Stems may be erect, twining, or prostrate; they, and other plant parts, may be hairy, pubescent, or free from hairs (glabrous).

Stems usually bear leaves spaced at more or less regular intervals. The specialized regions on the stem from which leaves arise are known as the nodes. The angle between the stem and leaf, from which secondary branches arise, is the axil. The portions of the stem between the nodes are the internodes.

The Leaf

Leaves are more diverse in form and arrangement than any of the other vegetative organs of plants. Most weeds can be recognized from their leaves alone.

Arrangement of leaves. Leaves may be borne on the aerial stem or may arise in a basal cluster from a stem crown. A basal cluster of leaves is a leaf rosette. Dandelions and plantains produce only rosette leaves; there is no leafy aerial stem. Other weeds, particularly winter annuals and biennials, first form a basal rosette and subsequently send up a leaf-bearing stem, e.g. wild carrot *(Daucus)*, bull thistle *(Cirsium)*, wild parsnip *(Pastinaca)*. Leaves borne on the aerial stem may be alternate, opposite, or whorled. Alternate leaves are produced singly at stem nodes and appear to alternate on the stem; opposite or paired leaves are borne two at each node; if three or more leaves are produced at each node, they are said to be whorled.

Parts of the leaf. A complete leaf consists of a stalk, the petiole, and a blade. Some leaves do not possess a petiole; i.e. the blade is attached directly to the stem. Such leaves are said to be sessile. The edge of the blade is the margin.

The stem nodes of many plants bear a pair of appendages (stipules), one on each side of the leaf. These structures may be bristle- or blade-like in form; they are sometimes fused and form a sheath about the node and lower portion of the leaf.

Form of the leaf blade. The leaf blade may consist of a single piece in which case it is said to be simple, or it may be divided into several secondary leaflets in which circumstance it is compound. If the leaflets are arranged along a main axis in feather-like fashion, the leaf is pinnately compound; if the leaflets arise from one point in finger-like fashion, it is palmately compound.

Leaf blades may be deeply cut or incised even though not divided into separate leaflets. Lobed leaves possess broad divisions; dissected leaves are cut into numerous, narrow lobes. Leaves may be pinnately lobed or dissected. Many leaves possess pinnately lobed leaves which are said to be pinnatifid.

Shape of the leaf blade. The following are among the more common leaf shapes: rounded, circular in outline; elliptical, shaped like an ellipse; ovate, similar to elliptical but broader towards the basal end, egg-shaped; lanceolate, narrow, broadest at the base and gradually tapering towards the upper end; linear, very narrow with parallel sides, e.g. leaves of grasses; cordate, heart-shaped; obovate and oblanceolate, similar to ovate and lanceolate respectively but with the broad end uppermost.

Margin of the leaf blade. If the leaf margin is untoothed it is said to be entire; if toothed with outwardly directed teeth it is dentate; if toothed with upwardly pointed teeth it is serrate. The teeth may be rounded or pointed.

The Flower

Flower arrangement. Ordinarily, flowers are borne in clusters or inflorescences. The more common types of inflorescences include: the spike, flowers sessile on an unbranched, elongate stem axis, e.g. a spike of wheat; the raceme, similar to a spike, but the flowers borne on stalks or pedicels; the panicle, similar to a raceme but branching, the flowers produced on the secondary or tertiary branches; the umbel, flowers borne on pedicels all of which arise from the same place at the apex of the stem, e.g. onion, carrot; the head, flowers sessile in a dense cluster at the apex of the stem, e.g. thistle; axillary cluster, flowers borne in the leaf axils and not segregated into a distinct inflorescence.

Flower structure. A complete flower contains calyx, corolla, stamens, and pistils or pistil.

The calyx is the outer envelope of the flower, composed of separate or fused lobes, the sepals.

The corolla makes up the conspicuous, commonly colored whorl of flower parts. The segments or lobes of the corolla are the petals. The corolla lies within the calyx, and its lobes usually alternate in position with those of the calyx. If the petals are partially or completely fused, the flower is said to be gamopetalous. In the majority of flowers the petals are of the same size and the flower is symmetrical in appearance; such flowers are said to be regular. Many flowers, however, possess petals of different forms or sizes; such flowers are not symmetrical (radially) and are said to be irregular.

The stamens are the male, or pollen-producing organs of the flower. The stamens lie immediately within the corolla. Each stamen possesses a stalk, the filament, which bears at its apex the pollen-producing anther.

The female portion of the flower located within the stamens is the pistil. It consists of a basal bulbous portion, the ovary, above which arises a stalk, the style, bearing at its apex one or several pollen-receptive stigmas. Inside the ovary are the ovules (one to many) which ultimately develop into seeds.

Some of the above parts are missing from many kinds of flowers. Such flowers are incomplete flowers. Sepals and petals may both be absent, e.g. grasses, or sepals present but petals absent, e.g. pigweeds. Unisexual or imperfect flowers, in which either the stamens or pistils are absent, are common in many kinds of plants. In Canadian thistle some plants produce staminate flowers (contain only stamens) and other plants produce pistillate flowers (contain only pistils).

Fertilization consists of the fusion of an egg and sperm cell (from which the new embryo plant ultimately develops), as well as fusion of another sperm with the so-called polar nuclei, this resulting in endosperm, a food storage tissue. Fertilization normally initiates the development of the fruit and seeds. In some plants modifications in the reproductive process allow development of the fruit and seed without fertilization; for example, fertilization does not usually take place in Kentucky bluegrass.

The Fruit

After fertilization, the calyx, corolla, and stamens usually wither or are variously modified. The ovary (sometimes surrounded by additional accessory structures) develops into the fruit, and the ovules into the seeds. The fruit may be dry or fleshy; it may contain one or many seeds; it may split open at maturity (dehiscent) releasing the seeds; or it may remain intact and fail to split open (indehiscent). Common types of fruits include:

Achene. A dry indehiscent fruit containing only a single seed. The fruit wall of the achene is closely associated with the seed coat but is usually distinct from it. The achene functions as a single seed. Examples: buckwheat *(Fagopyrum)*, sunflower *(Helianthus)* and thistle *(Cirsium)*.

Grain (caryopsis). The fruit of grasses. The grain is similar to the achene in that it contains only a single seed and is dry and indehiscent. It differs in that the embryo (germ) is usually visible at one end of the fruit and that the seed and fruit coat cannot be separated.

Capsule. A several-seeded, dry, dehiscent fruit usually containing several internal chambers. Examples: butterprint *(Abutilon)*, poppy *(Papaver)*.

Pod or legume. A dry, dehiscent or indehiscent fruit containing one to several seeds. If several seeds are present, they are lined up in one row within a single chamber. The pod is produced by members of the bean family. Examples: beans *(Phaseolus)* or peas *(Pisum)*.

Berry. A fleshy, indehiscent fruit containing several seeds. Examples: tomato *(Lycopersicon)*, grape *(Vitus)*.

The Seed

The seed, a matured ovule, represents the sexually produced reproductive unit of flowering plants. The "seed" of popular usage may be a true seed (beans, clover), or it may consist of a seed or group of seeds enclosed by various accessory structures. The commonest of such seed-like bodies are the one-seeded indehiscent fruits in which the seed is permanently enclosed within the fruit wall, such as the grain of grasses, the achene of smartweeds, or composites.

Seeds contain an embryo plant (or germ), a protective covering, and stored food which is used by the embryo in starting growth. The embryo consists of a partially developed root, stem, leaves, and one or two cotyledons or seed leaves. In the grasses and grass-like plants (monocotyledons) only one cotyledon is present; it is not leaf-like in appearance. In the broad-leaved plants (dicotyledons) two cotyledons are present, and they are usually leaf-like in appearance.

The seed coat is the protective covering of the seed. In many seed-like structures, particularly one-seeded fruits, the true seed coat is usually reduced, the protective functions having been assumed by the fruit coat, the pericarp.

The stored food may be incorporated within the embryo proper, usually in the cotyledons (beans). In other cases it makes up a special storage tissue, the endosperm.

The most valuable characters for identifying seeds are (1) the shape, (2) the nature and arrangement of markings (lines, ridges, pits, projections) on the seed surface, (3) the position and nature of the attachment scar (the hilum of true seeds), (4) the internal structure, position, and size of the embryo, presence or absence of endosperm.

GLOSSARY OF COMMON DESCRIPTIVE BOTANICAL TERMS

<u>Accrescent</u> - Closely pressed against or folded around.

<u>Alternate</u> - Leaf arrangement, one leaf at each node of the stem.

<u>Annual</u> - A plant whose life duration is a year or less.

<u>Anther</u> - The terminal, pollen-producing portion of a stamen.

<u>Apetalous</u> - A flower without petals.

<u>Auricle</u> - A lateral projection, one on each side, at juncture of sheath and blade of certain grass leaves.

<u>Awn</u> - A bristle-like tip; most frequently used with respect to bristle- or hair-like projections from glumes, lemmas, or paleas of grass spikelets.

<u>Axil</u> - The angle between a leaf and a stem in which branches or flowers may arise.

<u>Axillary cluster</u> - Referring to flowers or flower clusters borne in leaf axils rather than distinct inflorescences.

<u>Berry</u> - A fleshy, several-seeded fruit.

<u>Biennial</u> - A plant whose life duration is two years.

Bract - A modified, reduced leaf which subtends a flower or portion of an inflorescence.

Bulb - An underground, perennial, storage organ consisting of a stem axis and numerous, overlapping leaf scales.

Callus - Thickened tissue contiguous to the basal scar of a grass lemma.

Calyx - The outer whorl of flower parts; the sepals. The calyx is usually greenish and covers the other flower parts in bud.

Capillary - Thread-like.

Capsule - A dehiscent, dry several-seeded fruit.

Caryopsis - The grass fruit; one-seeded, indehiscent; seed coat scarcely distinguishable from fruit coat. Also called a grain.

Clasping - Descriptive of leaves, those which, usually sessile, possess a pair of basal lobes which tend to clasp about the stem.

Complete flower - A flower possessing all four whorls of flower parts: sepals, petals, stamens, and pistil.

Compound (leaf) - A leaf whose blade is divided into two or more distinct leaflets.

Cordate - Heart-shaped; usually used with reference to leaves with a pair of rounded basal lobes.

Corolla - The whorl of flower parts immediately inside of the calyx; composed of petals, usually colored.

Cotyledon - Seed leaf; the first leaf-like structures, usually paired, appearing above ground in most dicotyledonous plants. The cotyledons are often thick and fleshy and serve as food storage organs of the embryo plant. The so-called cotyledon (scutellum) of monocotyledons does not emerge from the seed.

Culm - The stem of a grass.

Dehiscent - Referring to a dry fruit which splits open at maturity releasing the seeds.

Dentate - Toothed, with the teeth directed at right angles to the edge. Usually employed with reference to leaf margins.

Digitate - With several parts or branches arising at or near the same point; finger-like.

Dioecious - A plant with unisexual flowers, the pistillate and staminate flowers being borne by different individuals.

Disk - Referring to the central portion of flower heads of members of the sunflower family and composed of tubular flowers in distinction to the marginal ligulate ones. The term is also employed with respect to individual tubular flowers, i.e. disk flowers.

Dissected (leaf) - A leaf whose blade is cut up into numerous, narrow lobes.

Drupe - A berry-like fruit with a hard endocarp and containing a single seed.

Drupelet - A small drupe.

Ellipsoidal - Elliptic in three dimensions, roughly football-shaped.

Elliptic - Shaped like an ellipse and essentially symmetrical.

Endosperm - A food storage tissue in seeds formed by the fusion of a sperm with the polar nuclei.

Entire - The margin of a leaf which is untoothed.

Fertilization - The fusion of the egg and sperm nuclei within the ovule of the pistil resulting in the initiation of the new embryo plant, and fusion of another sperm nucleus with the polar nuclei to produce endosperm.

Fibrous roots - A root system, as in grasses, composed of numerous, separate roots rather than one main root.

Filiform - Thread-like, very slender.

Filament - The stalk-like basal portion of a stamen.

Floret - A grass flower surrounded by lemma and palea.

Gamopetalous - Petals partially or completely fused.

Glabrous - Without hairs.

Glume - One of the two sterile bracts at the base of a grass spikelet.

Grain - The grass fruit; characterized by being one-seeded, indehiscent, with the seed coat scarcely distinguishable from fruit coat. Also called a caryopsis.

Hastate - Spear-head shaped; used especially with reference to leaves with a pair of basal lobes, these lobes directed outwards.

Head - An inflorescence in which the sessile flowers arise essentially from more or less the same level from a common, compound receptacle.

Herbaceous - Soft; lacking woody tissue. Used with respect to plants without woody tissue or with reference to the above-ground parts which do not live over winter.

Hilum - The attachment scar on a seed; the point of separation from its connection to the fruit.

Imperfect flower - A flower lacking either stamens or pistils; unisexual.

Indehiscent - Referring to a fruit which does not split open and release the seed or seeds at maturity.

Inferior - Referring to a flower, or its ovary, in which the other flower parts arise from the apex of the ovary rather than from below it.

Inflorescence - A cluster of flowers, or the flower-bearing portion or portions of a plant.

Internode - Portion of a stem between nodes.

Involucral bract - One of the several bracts surrounding or forming the lower part of the flower head in the sunflower family.

Irregular - A flower with petals which differ in size. Example: flowers of the legume family.

Lanceolate - Narrow and tapering from the base to the tip.

Leaflet - A secondary division of a compound leaf.

Lemma - The larger of the two bracts surrounding a grass flower.

Ligule - An appendage (a short membrane or row of hairs) on the upper side of the leaf at the juncture of the leaf and blade.

Ligulate (flower) - Strap-shaped, irregular flowers characteristic of the sunflower family. Ligulate flowers may constitute the entire head (dandelion) or make up the marginal petal-like flowers in those head types possessing both ligulate and tubular flowers (daisy).

Limb - Referring to the expanded or flattened portion of the corolla of many gamopetalous flowers.

Lobed - Shallowly or deeply divided into usually rounded sections or divisions; ordinarily employed with respect to leaves or leaf margins.

Margin - Edge of a leaf.

Mericarp - A seed-like fruit segment of the carrot family. The fruit, at maturity, splits longitudinally into two one-seeded, usually planoconvex segments, the mericarps.

Monoecious - A plant with unisexual flowers; both pistillate and staminate flowers borne by the same individual.

Node - That part of the stem from which leaves and branches arise.

Nutlet - Characteristic seed-like fruit segments of the mints and related families. The fruit splits longitudinally into four sections, each shaped like a quarter section of an orange; these are the nutlets.

Oblanceolate - Relatively narrow but broadening from the base to the tip.

Obovoid - Egg-shaped; broadest end uppermost or opposite point of attachment.

Ochrea - A membranous sheath surrounding the stem immediately above attachment of the leaves in members of the smartweed family.

One-celled - Referring to a pistil or ovary containing but a single chamber or cell inside.

Opposite (leaves) - The leaves paired at each node.

Ovary - The basal portion of the pistil containing the ovules.

Ovoid - Egg-shaped; broadest at the lower end.

Palea - The smaller of the two bracts surrounding a grass flower.

Palmately compound - A compound leaf in which the leaflets all arise from the same point.

Panicle - A branched inflorescence.

Pedicel - The stalk of an individual flower.

Peduncle - The stalk of an inflorescence or a part of an inflorescence, but not of an individual flower.

Perennial - A plant whose life duration may be several years.

Perfect (flower) - A flower which contains both stamens and pistils.

Pericarp - Fruit coat; used especially of the seed-coat-like covering of indehiscent, one-seeded fruits.

Perigynium - A sac-like structure surrounding the flower and fruit of *Carex*.

Petal - A single member of the second whorl of usually colored flower parts, collectively the corolla.

Petiole - The stalk of a leaf.

Pinnately compound (leaf) - A compound leaf in which the leaflets are arranged feather-fashion along an elongate axis.

Pinnatifid - A leaf whose blade is lobed in pinnate fashion.

Pistillate - Possessing only a pistil or pistils. May refer to a flower or to a plant.

Planoconvex - With one flat side and one concave side; turtle-shaped.

Pollen - The male, sex-cell-carrying units which, produced by the stamens, serve to carry out pollination.

Pollination - Transfer of pollen from the anther to the stigma. Note that pollination is not synonymous with fertilization, the latter referring to nuclear fusions within the ovule.

Pubescent - Possessing hairs; hairy.

Raceme - An unbranched inflorescence in which the flowers are stalked.

Rachilla - A short stalk, usually appressed against the lower portion of the palea of certain grass "seeds" (florets). Rachilla-possessing florets originate from several-flowered spikelets. The rachilla represents that portion of the spikelet axis lying between the two continguous florets.

Ray (flower) - Strap-shaped irregular (ligulate) flowers characteristic of the heads of certain members of the Compositae. Such flowers may make up the entire head or form the outer petal-like whorl.

Regular - Referring to flowers in which petals are equal, or approximately so, in size, the flower thus being radially symmetrical.

Rosette - A basal cluster of leaves not separated by evident internodal stem elongation.

Sagittate - Arrowhead shaped; used especially with reference to leaves possessing a pair of basal lobes, these lobes usually directed downwards.

Scapose - The inflorescence arising directly from the ground and not leaf-bearing.

Sepal - The outer whorl of flower parts, collectively the calyx. Usually the sepals are greenish and cover the other flower parts in bud.

Serrate - Toothed, the teeth slanting somewhat forward; usually employed with reference to leaf margins.

Sessile - A leaf or flower which is attached directly to the axis; without a petiole or pedicel.

Sheath - The tubular lower portion of a grass leaf surrounding the stem.

Silique - The fruit of the mustard family; typically two-chambered, dry, usually dehiscent.

Sinuate - Wavy; used especially with respect to leaf margins.

Spatulate - Spoon-shaped.

Spike - An unbranched inflorescence in which the flowers or flowering units are sessile.

Spikelet - The basic flowering unit within a grass inflorescence; consisting of a condensed stem axis bearing a pair of sterile bracts (glumes) at base and one or more florets above. The term spikelet is sometimes also employed with reference to similar flowering units in the sedge family.

Stamen - One of the male, pollen-producing organs of the flower. Consisting of a stalk, the filament, and the apical pollen-bearing anther.

Staminate - Possessing only stamens; may refer to a flower or to a plant.

Stigma - The terminal pollen-receptive portion of the pistil.

Stipules - Appendages, usually paired, arising from the stem at either side of petiole attachment; particularly characteristic of the legume family.

Stolon - A prostrate stem which roots at the nodes.

Style - The stalk-like part of the ovary which bears the stigma.

Subtend - To bear above; used especially with reference to a bract or a leaf which bears a flower in its axil.

Taproot - A root in which the main vertical axis predominates over the lateral branches, e.g. dandelion, carrot.

Tube - Referring to the basal tubular portion of many gamopetalous flowers.

Tuber - A swollen underground storage stem, e.g. a potato.

Tubular (flower) - Regular flowers characteristic of many members of the sunflower family. Such flowers may constitute the entire head or form the center portion of the head in those kinds which possess both tubular and ligulate flowers.

Umbel - An inflorescence in which the pediceled flowers arise essentially from the same point.

Whorled - A leaf arrangement; three or more leaves borne at each stem node.

Winter annual - An annual plant which usually initiates growth in the fall, lives over winter, and produces seed the following spring.

6. Weeds of the North Central States

IN THE FOLLOWING CHAPTERS the more common or important weeds and weed groups of the North Central States are described. It is desirable to consider briefly the manner of treatment and the uses which may be made of this part of the text.

RECOGNITION AND IDENTIFICATION

Weeds and weed groups are distinguished in terms of their structure and appearance. Many of the distinctions are on specific characters of flowers and fruit, and technical terms (previously reviewed) are employed to present the descriptions. Since it is possible, however, to recognize many weeds without recourse to botanical characters, it is natural to inquire concerning the necessity of technical descriptions or why relatively inconspicuous characters are often employed.

There is a difference between recognition and identification. One recognizes a friend by a large number of subjective and variable features which he assembles more or less subconsciously. If it were possible to catalogue all of the characters which are involved and necessary in recognizing an individual or a plant, the description might be pages long. Futhermore, recognition is usually possible only after a period of close association with the subject under consideration.

On the other hand, identification is concerned with the conscious use of relatively few characters which experience has indicated to be relatively constant and which can be used as "signposts." Such characters are frequently those which have evolutionary significance in the interpretation of plant classification; they must have a genotypic as well as phenotypic basis and not be influenced by environmental factors. In some instances, from the standpoint of gross size, they are small or insignificant characters.

In order to learn individual species and plant groups in an efficient and orderly fashion, one must proceed through the mental process of identification. Once he is able to identify the plants concerned, and continues to work with them, he will begin to be able to recognize them. Subsequently he may largely dispense with conscious identification and depend almost entirely upon recognition. Botanists who "know" many plants probably recognize most of them. Nevertheless, they frequently fall back upon identification characters for verification if for one reason or another they are uncertain of their recognition reaction. They then follow the same conscious process employed in originally learning the species.

PLANT FAMILIES AND GENERA

It goes without saying that an individual working with weeds should know the common species. He should also have some knowledge of methods of identifying unfamiliar kinds or to verify ones partially forgotten. Botanists identify plants by employing botanical keys — outline forms which through a series of alternative choices lead to the name of the plant. It is frequently possible to short-cut the employment of keys by learning the characteristics of plant groups, families, and genera. If the family to which an unknown belongs can be easily identified (or recognized), much of the job of identification is completed. It is necessary only to search for the plant in a book or bulletin within the confines of that specific group. Furthermore, if one is familiar with the family to which an unknown weed belongs, he will automatically know a great deal about it. For example, he may be able to hazard a guess as to its sensitivity to 2,4-D; e.g. members of the grass family are highly resistant to this herbicide while the mallow family is quite susceptible.

METHOD OF TREATMENT

The following chapters present brief descriptions of the more common or important weedy species of the North Central States. It is not practical to consider all kinds if the treatment is to be maintained within usable limits. As an alternative, and for the reasons given above, many weed groups, families and genera, have been characterized.

The sequence of treatment, inasfar as arrangement of families is concerned, is essentially that employed in most botanical manuals except that grasses and other monocotyledons have been placed at the end. Since the grasses constitute a technical group, it is usually easier for the beginning student to work with them subsequent to gaining experience with other plant families.

The descriptions presented include not only weeds but also the common agricultural species of the North Central States. Too often weedy and crop species are confused, or determination of a weed (especially a grass) is tentative because of uncertainty that it may be a planted species. Accurate identification of weeds predicates a knowledge of the plants with which they grow and of the distinctions between them.

The diagnoses are not complete descriptions; the latter would consume much more space. They present only the more important characters, especially those useful in distinguishing each from similar kinds with which they are easily confused. If employed with specimens, the diagnoses are useful in pointing up what to look for in learning the plants, and they help avoid the pitfall of reliance on undependable characters which chance to be conspicuous on a given specimen. As a useful adjunct to these descriptions, the pictures in the regional bulletin "Weeds of the North-Central States" (see Chapter 25) are useful in learning many of the weed kinds.

Seeds of some weed kinds are frequent contaminants of agricultural seed. Such seeds are briefly characterized and the nature of their occurrence in crop seed given.

Brief statements as to range, habitat, and seasonal time of abundance or blooming follow the descriptions. Statements as to range, i.e. "western," "southeastern," apply specifically to distribution within the North Central States, not the United States as a whole.

Classification of Weeds by Family Characteristics

7. Nettles and Smartweeds

URTICACEAE, NETTLE FAMILY

LEAVES OPPOSITE, or upper ones alternate, simple or compound. Flowers greenish, without petals, in hanging, catkin-like spikes or clusters in axils of leaves. Fruit an ovoid achene.

Cannabis. *Cannabis sativa*, Hemp, Marijuana weed. Plants annual, p38 erect, 1-3 mm. tall. Leaves palmately compound with 5-7 narrowly lanceolate leaflets. Waste areas, fence rows, around farm buildings, usually on bottom land soil. Less common in eastern and western extremities of North Central States. Summer.

Urtica, Stinging nettle. Plants perennial from creeping rootstocks. p38 Leaves simple, ovate to lanceolate, serrate. Entire plant, especially stems, with coarse, stinging hairs. Mostly rich, uncultivated soil, locally abundant.

POLYGONACEAE, SMARTWEED FAMILY

Leaves alternate or basally clustered, entire. A membranous sheath (the ochrea) encircles the stem above the node in all weedy species. The flowers possess no petals but the calyx is colored in smartweeds. Fruit a flattened or three-angled achene, frequently surrounded by the persistent calyx. Seeds (the achenes) blackish or brown, usually smooth and hard. Embryo longitudinal in abundant endosperm.

The Polygonaceae is one of our more important weedy families. The following, as well as other species, are common over much of the United States. Numerous members of the genus *Eriogonum* (buckwheat-brush, skeleton weed) are common in the West on rangeland and in the mountains. Buckwheat *(Fagopyrum esculentum)* and rhubarb *(Rheum rhaponticum)* are members of the smartweed family.

Rumex, Dock and Sheep sorrel. Plants perennial with a conspicuous cluster of basal leaves in the fall and spring. Flowers in a terminal panicle, greenish, turning brown and often enlarging in fruit, the calyx lobes persistent, surrounding the fruits. Achenes brown, three-angled, commonly with sharp edges. In cross section, the embryo may be found in one of the corners of the achene. The docks are common weeds of grain crops and grassland. They are secondary noxious or restricted weeds in most states.

Rumex crispus, Sour dock, Curly dock. Leaf margins irregularly wavy or curled. Calyx lobes loosely adherent about a-
p39 chenes. Achenes 2-2.5 mm. long. Common or abundant, grassland, legume seedings, small grains. Early summer.

Seeds common in legumes, forage grasses, and cereals. In red clover and small-seeded grasses, the achene (of the dock) is usually hulled out of the persistent calyx; in oats the "seed" commonly consists of the achene plus hull (calyx).

Rumex altissimus, Smooth dock. Leaf margins smooth. Achenes similar to those of sour dock but calyx lobes sur-
p40 rounding fruit much larger. Mostly south central portion, in similar areas as sour dock but usually less common.

Rumex obtusifolius, Broad-leaved dock. Leaves basally cordate. Calyx lobes toothed. Achenes essentially indistinguish-
p41 able from those of sour dock. A common weed of the eastern and southern states, this plant occurs primarily in the southeastern portion of our range.

Rumex acetosella, Sheep sorrel, Red sorrel. Plants perennial from creeping roots, smaller in stature than the docks. Leaves with a pair of outwardly directed basal lobes. Achenes
p40 (seeds) smaller than those of dock, about 1 mm. long, bluntly angled; calyx lobes closely adherent, and usually persistent, even in processed seed. West to eastern Kansas and Dakotas, diminishing with reduction in rainfall. Pastures, grassland, often in poor soil. Early summer. Seed frequent in commercial clover and forage grass seed.

Polygonum, Smartweeds. Plants mostly annual, not possessing a cluster of basal leaves. Flowers white or pinkish; sepals petal-like, not enlarged in fruit. Seeds most commonly black, three-angled or flattened, the corners rounded; persistent calyx lobes frequently close-fitting about seed. Embryo in cross section placed in corner of seed.

The smartweeds include several of the most ubiquitous and abundant weeds of cultivated soil. In addition to the most common kinds, treated below, a number of other species are of general occurrence throughout much of the North Central States. These, mostly with whitish-green flowers, are frequently seen in wet pastures and along streams. They are often called water peppers.

Polygonum persicaria, Common smartweed, Ladysthumb. Leaves lanceolate. Ochrea bristly at apex. Flowers dull pink. Achenes shiny black, about 2 mm. long, usually flat, but some-
p42 times three-angled. Very abundant in cultivated soil, especially corn and soybeans, throughout range. Summer and fall. Seeds common in oats, soybeans, and clovers.

Polygonum pensylvanicum, Pennsylvania smartweed. Similar in appearance to common smartweed, but ochrea not bristly.
p43, Flowers bright pink or pinkish-white Achenes flat, larger (3
p44 mm. long) than those of ladysthumb. Common in cultivated soil. Summer and fall. Seed frequent in oats and soybeans.

Polygonum aviculare, Knotweed. Plants smaller than above species, prostrate or low with axillary, pinkish-white flowers. p45
Seed three-angled, dull-brownish, about 2 mm. long. Can probably stand more foot and vehicular traffic than any other plant. Common in towns and around buildings, paths, roadsides, lawns, waste areas. Entire season.

Knotweed is extremely variable as to habit and leaf shape; some of the extremes may scarcely be recognizable as the same kind of a plant. Additional knotweed-like species occur in our range, particularly the western portion; these plants are usually considerably taller than the common knotweed and tend to have broad, yellowish-green foliage.

Polygonum convolvulus, Wild buckwheat, Black bindweed. Stems twining or creeping. Leaves ovate, pointed, with a pair of downwardly directed basal lobes. Flowers in axillary clusters, p46
greenish-white. Achenes large, 3-3.5 mm. long, black, three-angled, surrounded by persistent calyx lobes. Common, fences, roadsides, cultivated soil. Summer. The seeds are common in seed oats.

Wild buckwheat is often confused with field bindweed (a primary noxious or prohibited weed) and hedge bindweed, especially before flowering. Distinctions of wild buckwheat: plant with an annual taproot; ochrea present on stem; flowers small (less than 1 cm. across), in greenish-white clusters. Field bindweed and hedge bindweed: plants from deep perennial roots; ochrea not present; flowers large (2-4 cm. across), morning-glory-like in appearance.

Polygonum coccineum, Devil's shoestring, Tanweed, Marsh smartweed. Our only common smartweed which is perennial, p47
growing from wiry, blackish roots. Plants erect; leaves and stem finely pubescent. Flowers bright pink but blooming infrequently. Characteristic of poorly drained soil, roadside ditches, low fields, marshy waste areas, rarely seen in flower. Summer.

PLATE 1

Urtica dioica 1. Habit x2/3.
Cannabis sativa 2. Leaf x2/3.

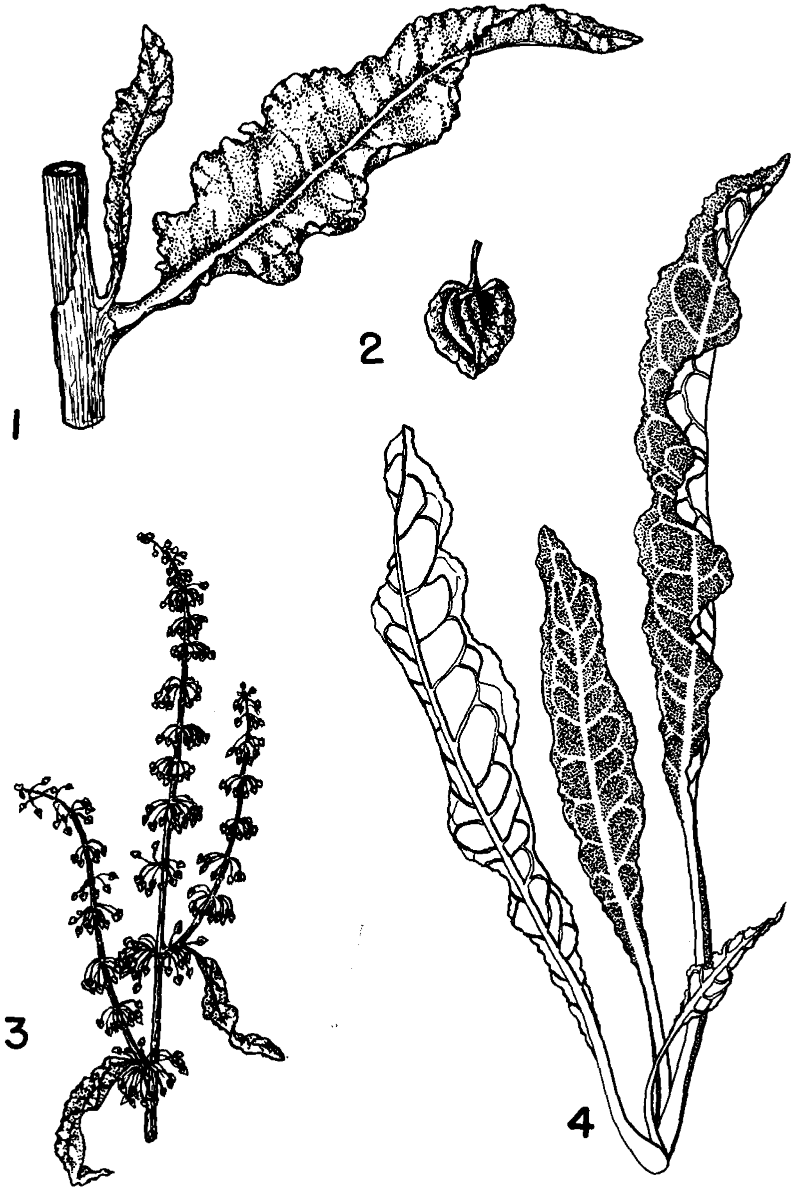


PLATE 2

Rumex crispus 1. Leaf and ochrea x2/3. 2. Fruiting calyx x3. 3. Inflorescence x1/3. 4. Rosette leaves x2/3.

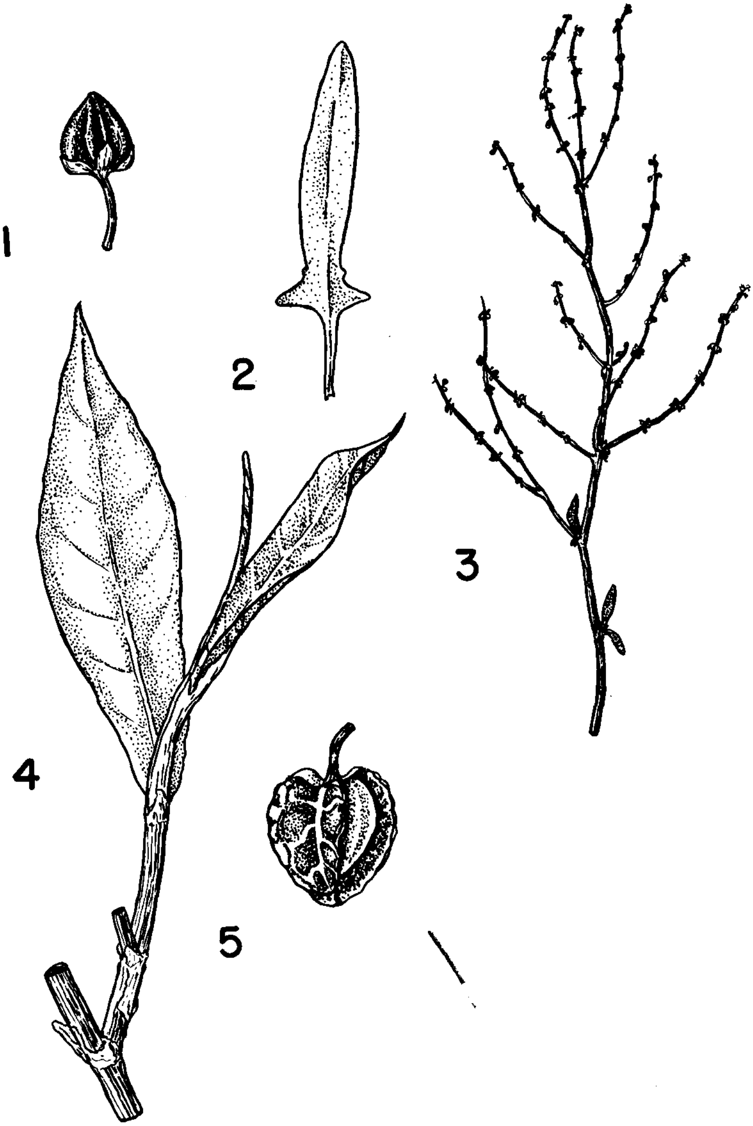


PLATE 3

Rumex acetosella 1. Fruiting calyx x5. 2. Basal leaf x2/3. 3. Inflorescence x2/3.
Rumex altissimus 4. Leaves and ochreae x2/3. 5. Fruiting calyx x3.

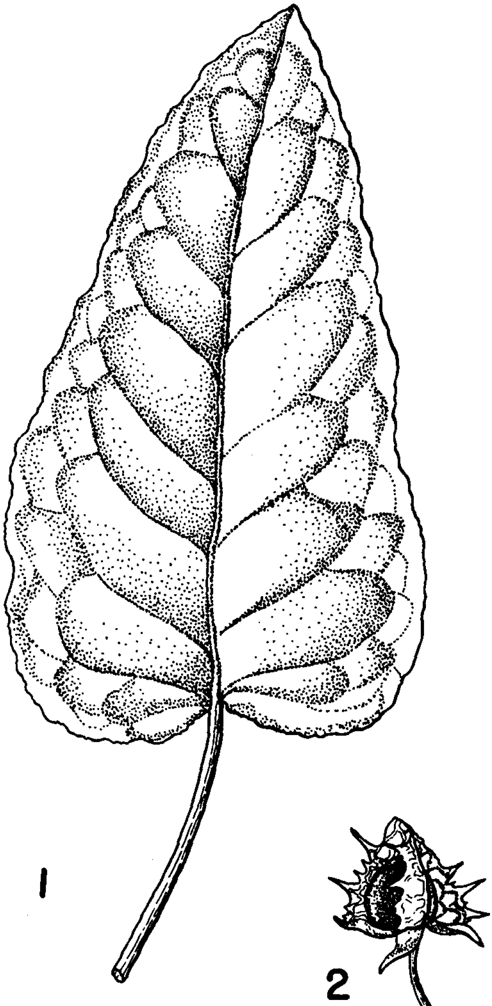


PLATE 4

Rumex obtusifolius 1. Basal leaf x1/3. 2. Fruiting calyx x3.

PLATE 5

Polygonum persicaria 1. Inflorescence x2/3. 2. Lower leaf and ochrea x2/3. 3. Achene x3.

PLATE 6

Polygonum pensylvanicum 1. Inflorescence x2/3. 2. Lower leaf and ochrea x2/3. 3. Achene x3.

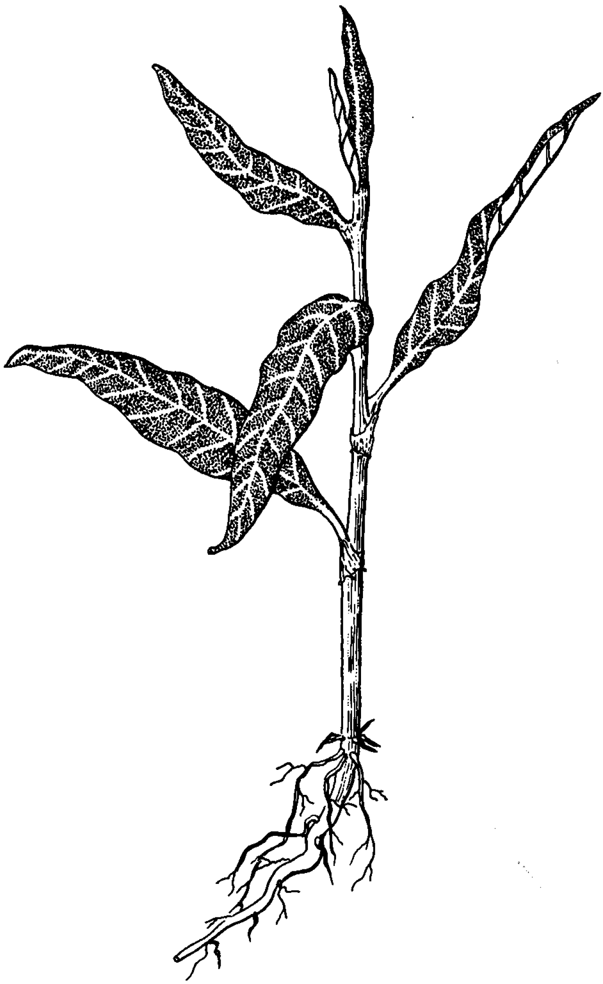


PLATE 7

Polygonum pensylvanicum Young plant x2/3. No basal rosette as in *Rumex*.

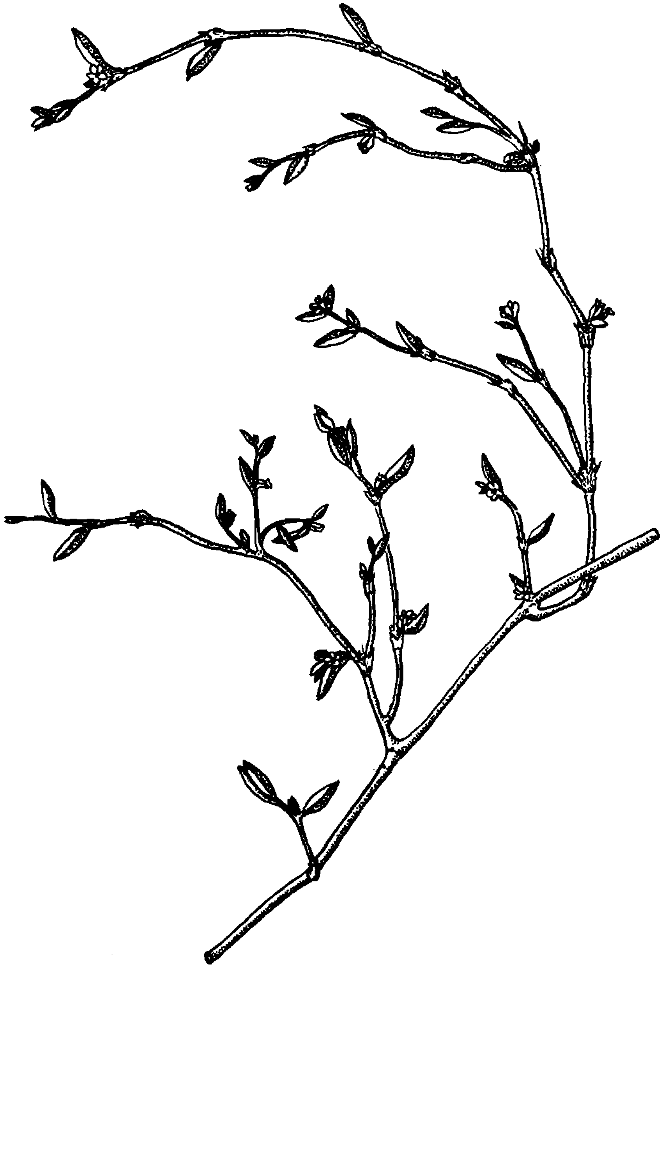


PLATE 8

Polygonum aviculare Habit x1 1/3.

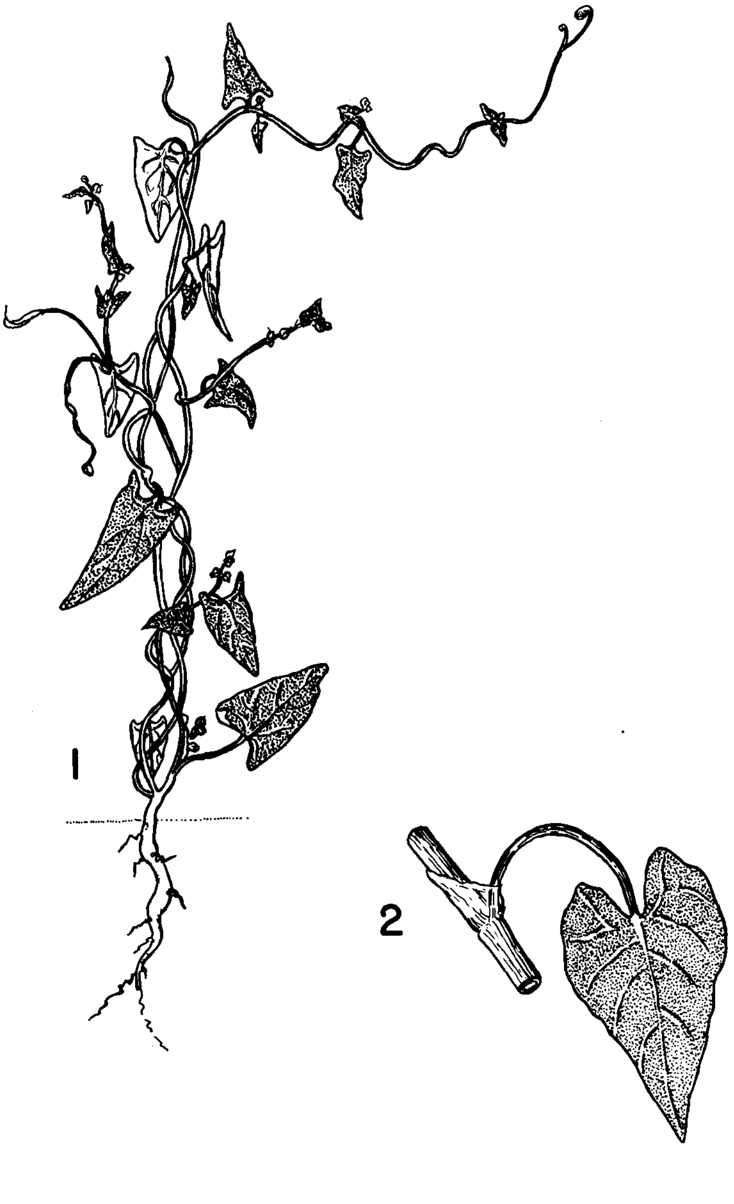


PLATE 9

Polygonum convolvulus 1. Habit x1/3. 2. Leaf and ochrea x1.

PLATE 10

Polygonum coccineum Lower stem and root x2/3.

8. Pigweeds and Relatives

AMARANTHACEAE, PIGWEED FAMILY

PLANTS ANNUAL. Leaves alternate or opposite (alternate in our weedy species). Flowers small, without petals, subtended by small bristly bracts. Fruits one-seeded, the thin pericarp in our weedy members releasing the lens-shaped, shiny black seeds.

The seeds in this and the following groups, as well as the Pink family, are similar in that they are usually rounded or horseshoe-shaped and possess a marginal embryo surrounding a central, stored food tissue. Presumably they are evolutionarily related, the pigweeds and relatives having been derived from Pink-like ancestors through loss of petals and reduction of the several-seeded capsule of the Pinks to a one-seeded fruit.

Amaranthus, Pigweeds. Flowers perfect or some of them unisexual but all in the same inflorescence; plants similar to one another as to flowering habit (contrast with *Acnida* below).

There are species of pigweeds in all parts of the country, and they are among the more common invaders of cultivated soil and waste areas.

Amaranthus retroflexus, Rough pigweed, Redroot pigweed.
Plants erect, with dull, usually pubescent, ovate-lanceolate
p51 leaves and dense terminal spikes of flowers. Seeds small,
1.0-1.2 mm. across. Abundant, cultivated land, gardens, farm
lots. Summer and fall. Seeds common in legume, oats, and
soybean seed.

Amaranthus graecizans (A. blitoides), Prostrate pigweed.
Plants prostrate. Flowers in inconspicuous clusters in the
p52 axils of the leaves. Seeds similar to those of *A. retroflexus*
but larger, 1.5 mm. in diameter. Common, gardens, fields.
Late summer and fall.

Amaranthus albus (A. graecizans), Tumbling pigweed. Plants
erect, densely branched, becoming almost spherical at maturity. Flowers in axillary clusters. Seeds nearly indistinguish-
p52 able from those of *A. retroflexus*. Most common in western
extremities of range but locally abundant throughout, cultivated
and waste ground. Late summer and fall.

Amaranthus spinosus, Spiny pigweed. Similar to rough pigweed
in appearance but with spiny branches. A southern weed which
p53 occurs only in the southern portion of our range.

Acnida, Water hemp. Plants similar to rough pigweed in appearance,
but with narrower, smoother leaves. Flowers imperfect and plants di-
oecious, the inflorescences of the male and female plants somewhat dif-
erent in appearance. Most common in the south central part of our p54
range, low uncultivated or cultivated areas. Late summer and fall.
Two alleged species occur in the north central area, but a large propor-
tion of our representatives are hybrid populations.

CHENOPODIACEAE, GOOSEFOOT FAMILY

Annual weeds. Similar to above but without bristly bracts. The fruit pericarp is more or less adherent to the seed as a scurfy covering.

The goosefoot family is one of our major weedy groups from the standpoint of number of species. Beyond those treated below, a number of genera and species are common weeds elsewhere in the country and occur occasionally in the Midwest. Some of these unfortunately have the common name of pigweed (e.g. *Cycloloma*, winged pigweed; *Axyris*, Russian pigweed) but are not members of the pigweed family. Spinach (*Spinacia*), beets, sugar beets, and Swiss chard (all *Beta*) are typical representatives of the Chenopodiaceae.

Chenopodium. Leaves various, often broad or variously lobed. Flowers greenish, usually several to each bract or reduced leaf. Fruits circular or disk-shaped, surrounded by the accrescent sepals. Pericarp membranous, indehiscent, somewhat adherent to the single seed. Seeds black, similar to those of pigweeds, but less shiny, often marginally lobed or furrowed around the edge of the embryo.

The "seeds" may be encountered in agricultural seed as the fruit surrounded by the sepals, the sparated fruit (with pericarp intact or partially destroyed), or the true seed, depending upon the degree of processing to which they have been subjected.

At least half a dozen species of *Chenopodium* are weedy in nature. Some of them are very similar to lambsquarter, described below, and distinctive only by technical characters. *C. ambrosioides* (wormseed, Mexican tea) with pinnately lobed leaves and a strongly aromatic odor is occasional in uncultivated areas and around buildings.

> *Chenopodium album*, Lambsquarter. Plants annual, erect.
> Leaves irregularly lobed, pointed, usually somewhat whitish
> beneath. Flowers in simple or branched spikes. Seeds nearly p55
> circular, 1.2-1.5 mm. in diameter, dull black or scurfy in ap-
> pearance. Locally abundant. Summer and fall. Seeds common
> in legume seeds.

Kochia. *Kochia scoparia*, Kochia, Firebush. Annual, very densely leafy
with lanceolate blades, at maturity with numerous spreading branches p56,
which bear flowers, 1 each in the axils of slender leafy bracts. Seeds p57
brownish, horseshoe-shaped, 1.7-2.9 mm. long. Roadsides, fence rows,
uncultivated areas, legumes. Late summer and fall. Seeds often abun-
dant in commercial alfalfa seed.

Atriplex. Atriplex patula, Orache, Saltbush. Leaves triangular, some-
p57 what hastately lobed. Fruits similar to those of lambsquarter but larger,
and enclosed, clamshell-fashion between a pair of triangular bracts. Moderately common in western portions of range, occasionally elsewhere. Seeds occur in legume and grass seed.

Salsola. Salsola kali, Russian thistle. Leaves narrow, thick, at maturity becoming spine-tipped. Fruit top-shaped with embryo coiled up
p58 spirally. Common in regions of low rainfall, in the western states
rangeland, waste areas, grains, and legumes. Occasional, mostly in noncultivated soil, further east.

Mirabilis. Mirabilis nyctaginea, Wild four-o'clock. A forked-branching
p59 perennial with opposite, cordate leaves and reddish flowers enclosed by
large bracts. Local, roadsides, and railroad rights-of-way.

PHYTOLACCACEAE, POKEWEED FAMILY

Phytolacca americana, Pokeweed, Pokeberry. A tall perennial from a fleshy root, with alternate, ovate-lanceolate leaves. Flowers white in
p60 axillary racemes. Fruit a fleshy, purple berry with several seeds
similar in appearance to those of pigweed but larger. Summer and fall. Southern part of range only, pastures, roadsides, often in open, wooded areas. The plant is poisonous to livestock.

rough pigweed

PLATE 11

Amaranthus retroflexus 1. Calyx and fruit, semi-diagrammatic showing seed inside x7. 2. Habit x2/3.

PLATE 12

Amaranthus graecizans 1. Habit x2/3.
Amaranthus albus 2. Habit x2/3.

PLATE 13
Amaranthus spinosus Habit x2/3.

PLATE 14

Acnida sp. Habit x1/2.

PLATE 15

Chenopodium album 1. Fruiting calyx x7. 2. Inflorescence x1/2. 3. Lower leaf x1/2.

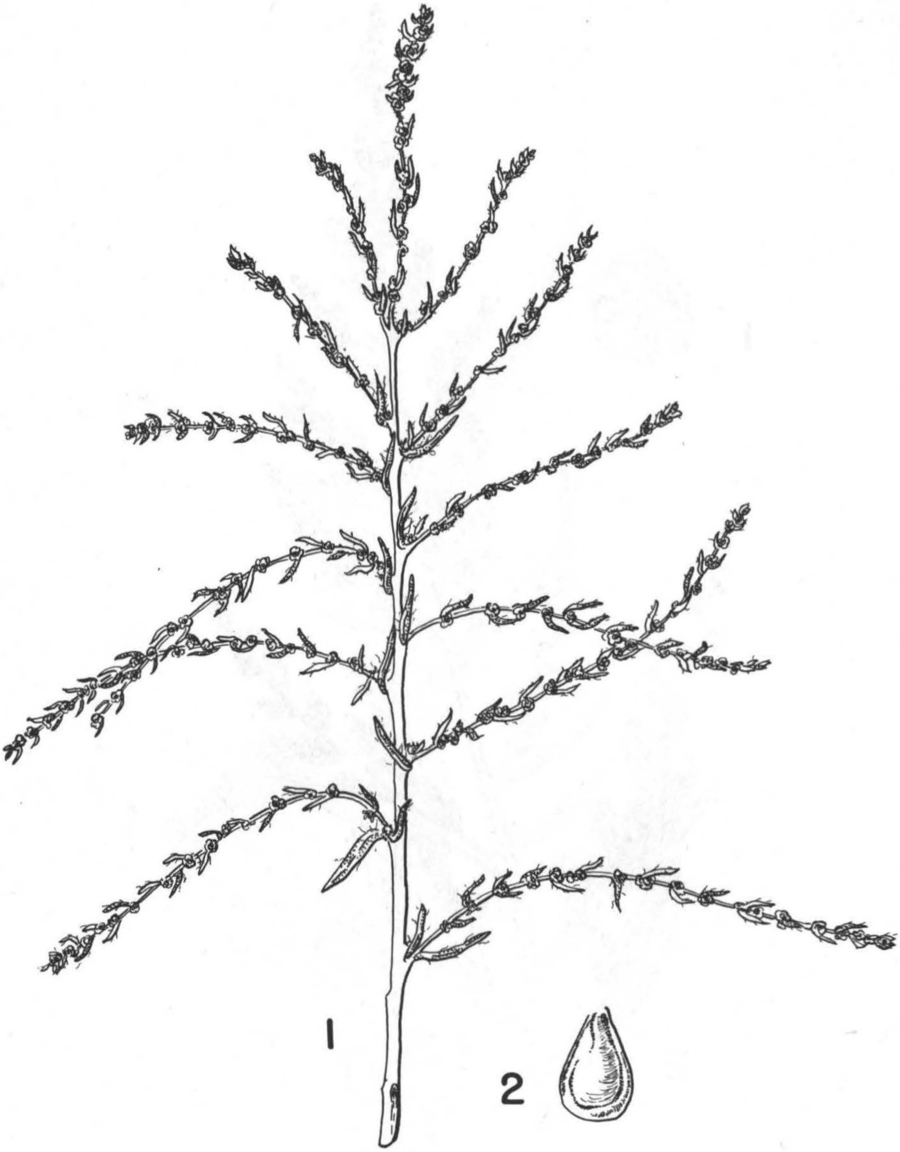


PLATE 16

Kochia scoparia 1. Inflorescence x2/3. 2. Seed x7.

PLATE 17

Kochia scoparia 1. Young plant x2/3.
Atriplex patula 2. Fruiting bracts x5. 3. Portion of inflorescence and leaves x2/3.

PLATE 18

Salsola kali 1. Young plant x2/3. 2. Branch of mature plant x2/3.

PLATE 19

Mirabilis nyctaginea Habit x2/3.

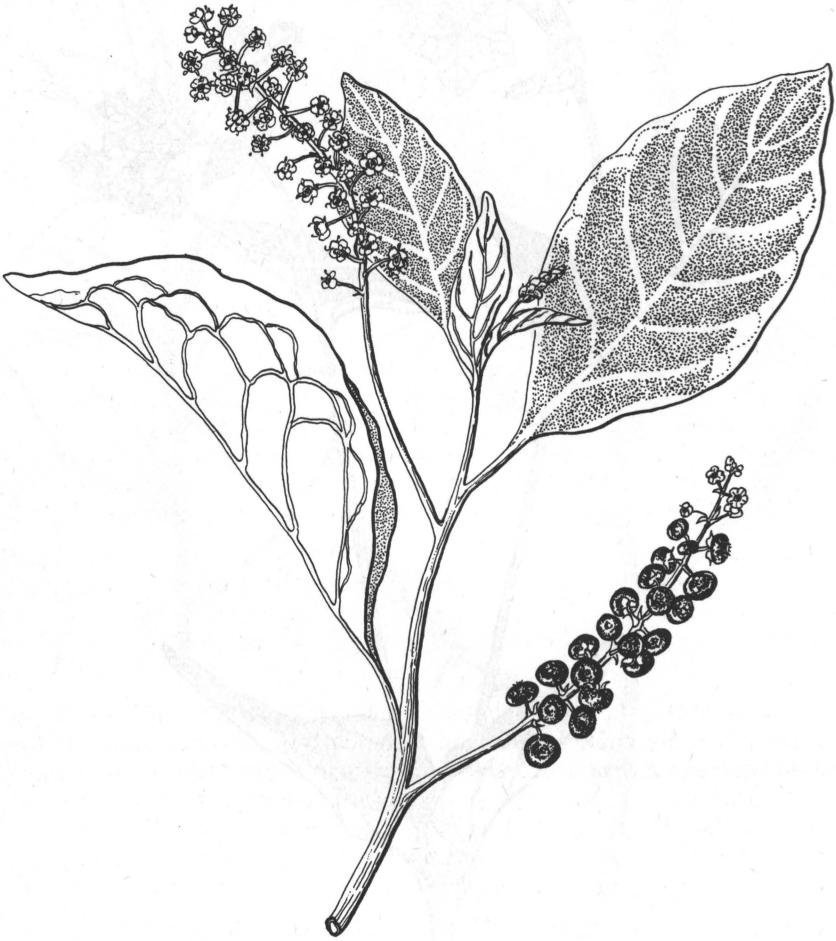


PLATE 20

Phytolacca americana Inflorescence and leaves x2/3.

9. The Pink Family and Similar Weeds

CARYOPHYLLACEAE, PINK FAMILY

LEAVES OPPOSITE (sometimes whorled), entire, rarely petioled, arising from swollen stem nodes. Flowers conspicuous with colored petals. Fruit a several-seeded capsule with a single internal chamber. Seeds with the same structure as those in Amaranthaceae and Chenopodiaceae but not circular, usually thicker and warty.

This family contains a number of weeds, most of which, however, are not major pests. Garden pinks and carnations are cultivated members of the Caryophyllaceae. The seeds of some are poisonous.

Lychnis. *Lychnis alba*, White campion, White cockle. Biennial or perennial. Leaves hairy. Flowers white. Seeds 1.2-1.3 mm. across, gray, p63
finely warty. Common, mostly northern and eastern states, along roadsides, in waste areas, and legume seedings. Summer. The seeds are frequent in red clover seed.

Silene, Catchflys. Several species, annual or perennial, similar in appearance to white cockle, differing technically in the possession of three
styles, whereas *Lychnis* has five. *Silene noctiflora* (night-flowering p64,
catchfly) is sticky-hairy. *Silene antirrhina* (sleepy catchfly) has stems p65,
with sticky bands; flowers small, 3-4 mm. across. *Silene cucubalus* p66
(bladder campion), glabrous with broad leaves and inflated capsules. These plants are most common in eastern and northern part of range.

Agrostemma. *Agrostemma githago*, Corncockle. Winter annual or bi-
ennial. Plants hairy. Leaves narrowly oblong. Flowers purple-red. p67
Spring and early summer. Mostly southeastern portion of range. Waste areas and winter grain. The seeds are poisonous, and their presence in screenings used for feed may result in animal poisoning. Wheat containing corn cockle seeds is subject to heavy dockage.

Saponaria. *Saponaria officinalis*, Bouncing bet. Plant perennial, gla-
brous. Flowers closely clustered, pinkish to lavender. Early summer. p68
Roadsides, railroad rights-of-way, waste areas, mostly eastern.

In addition to the above, *Saponaria vaccaria*, Cow cockle, occurs in the northwestern portion of the North Central States, mostly in spring grain areas. The pinkish flowers are not closely clustered. The seeds are globose and, like those of corn cockle, are poisonous.

Stellaria. Stellaria media, Chickweed. A low, creeping plant with small p69 spoon-shaped leaves and white flowers. Seeds very small. Most common in eastern states, especially in shady or wet lawns. Summer and fall. Seeds common in lawn seed.

p69 *Cerastium. Cerastium vulgatum,* Mouse-ear chickweed. Similar to *Stellaria* but densely hairy.

PORTULACACEAE, PURSLANE FAMILY

Portulaca. Portulaca oleracea, Purslane, Pussley. Plants annual, glabrous, nearly prostrate, with thick fleshy stems and leaves. Flowers p70 small, yellow. Fruit a capsule producing numerous small, shiny, black seeds. Locally abundant in cultivated soil. Summer and fall.

AIZOACEAE, CARPETWEED FAMILY

p70 *Mollugo. Mollugo verticillata,* Carpetweed. Prostrate with whorled leaves and small white flowers. Locally common in sandy soil, especially southeast. Summer and fall.

PLATE 21

Lychnis alba 1. Mature fruit x2. 2. Pistil x3. 3. Inflorescence x2/3.

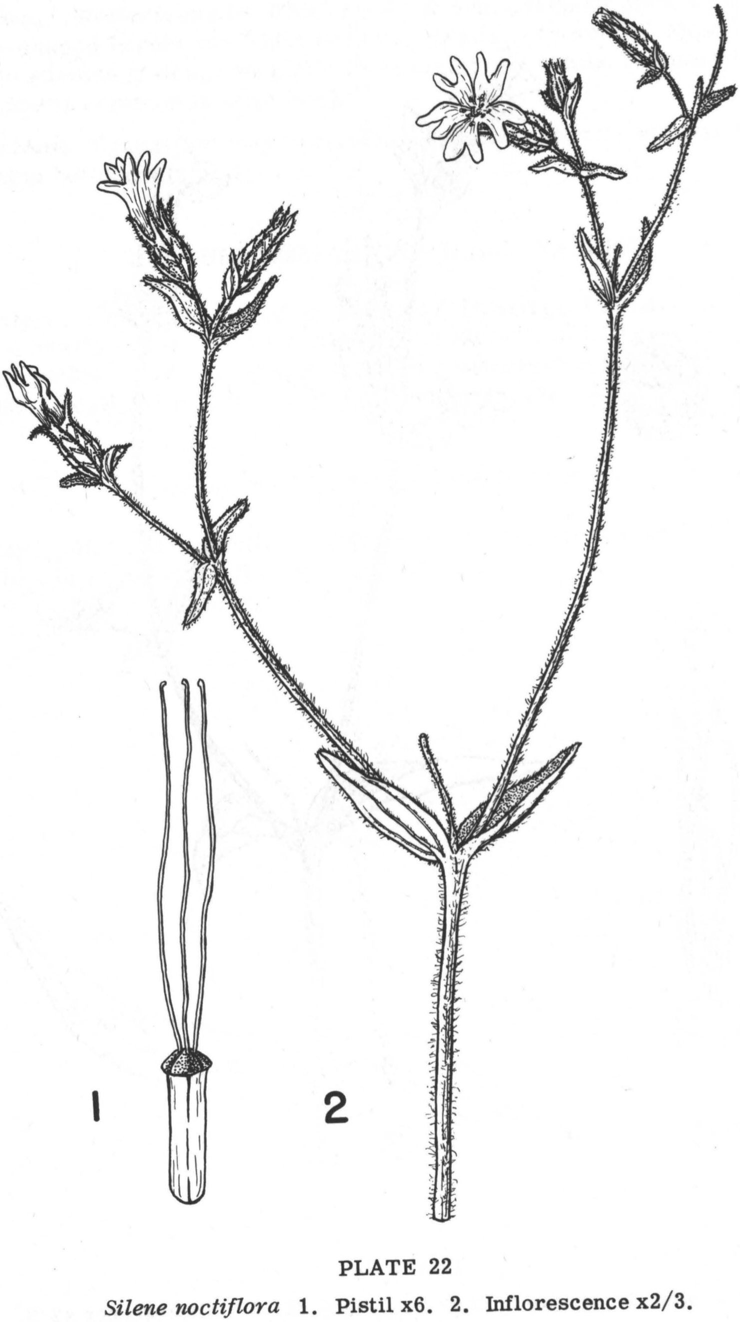


PLATE 22

Silene noctiflora 1. Pistil x6. 2. Inflorescence x2/3.

PLATE 23

Silene antirrhina Habit x2/3.

PLATE 24
Silene cucubalus Habit x2/3.

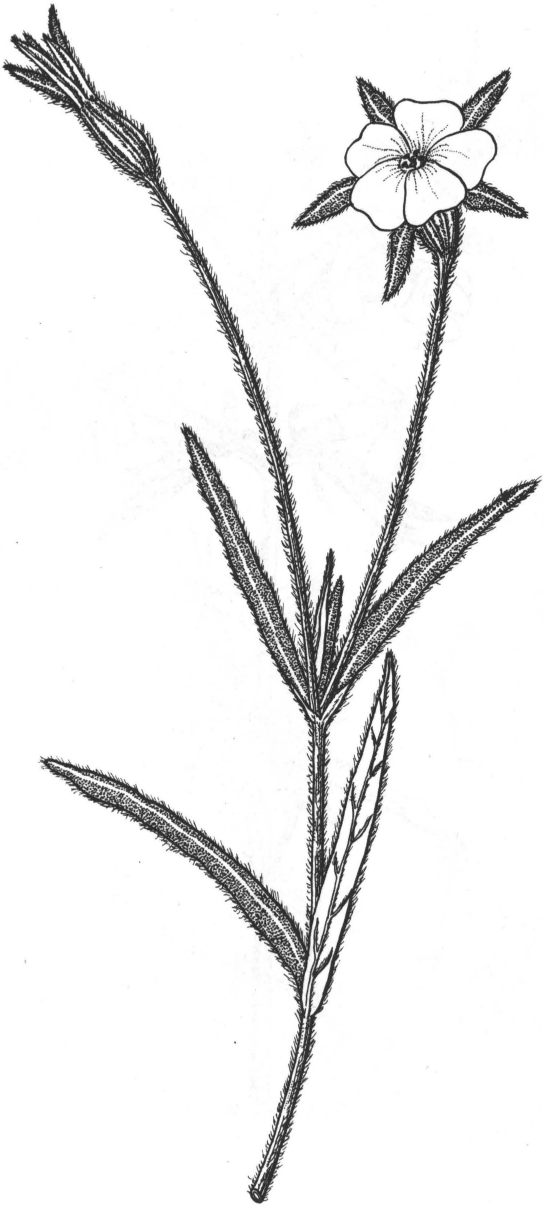


PLATE 25

Agrostemma githago Apex of plant x2/3.

Bouncing Bet

PLATE 26

Saponaria officinalis Apex of plant x2/3.

PLATE 27

Stellaria media **1. Habit x1 1/3.**
Cerastium vulgatum **2. Habit x2/3.**

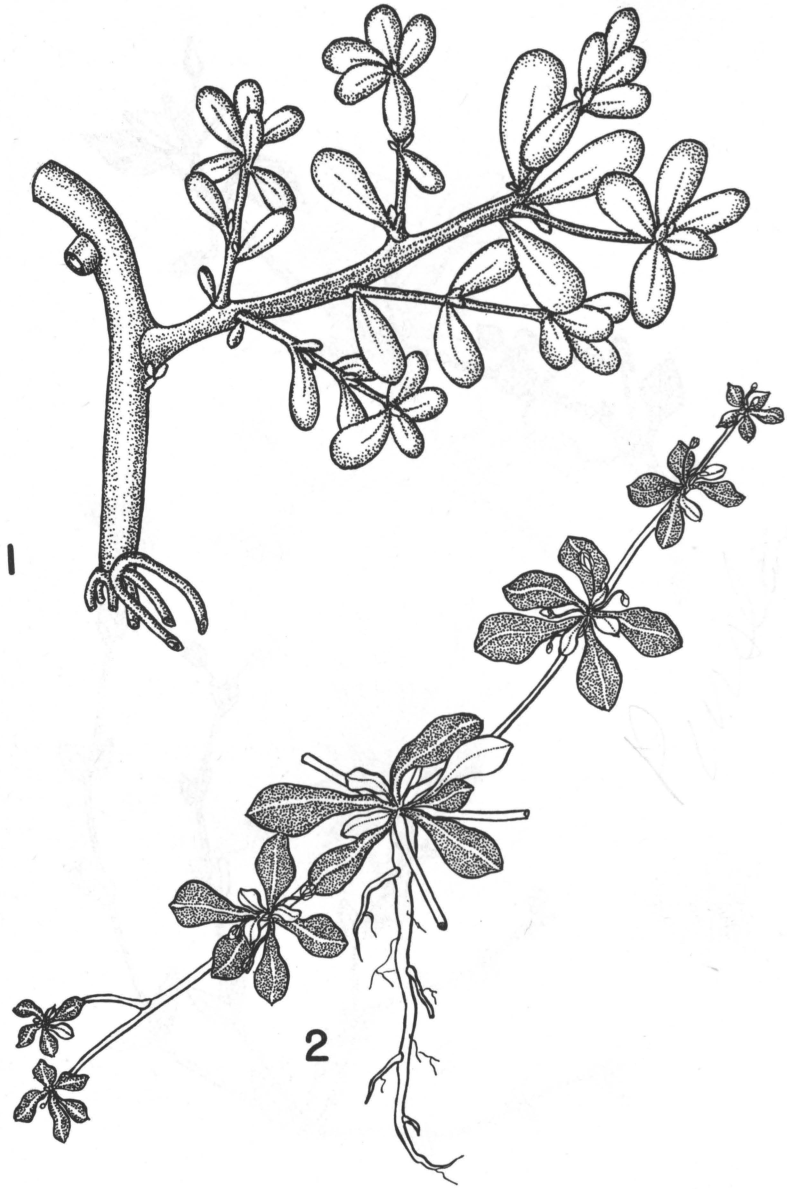


PLATE 28

Portulaca oleracea 1. Leafy branch x2/3.
Mollugo verticillata 2. Habit x2/3.

10. The Cruciferae, Mustard Family

LEAVES ALTERNATE. Flowers "cross-like" with 4 sepals, 4 petals, and 6 stamens. Fruit a silique, pod-like, or short and flattened, with two chambers separated by a central partition, bearing two to several seeds, usually dehiscent. Seeds various in shape, usually with a thin seed coat which is pitted or marked with a network of lines. Embryo variously folded. Endosperm not present.

The mustard family contains a great diversity of weeds over the entire United States. Many are winter or early spring annuals and are most conspicuous in the spring. The annual mustards *(Brassica)* and perennial peppergrass or whitetop *(Cardaria)* are the kinds most frequently considered noxious.

The majority of mustards possess fall or spring rosettes from which the leafy stem subsequently develops. Frequently the rosette and lower stem leaves are of different form than the later upper stem leaves. For instance, in *Sisymbrium altissimum* (tumble mustard), the lower leaves are pinnatifid or pinnately compound with coarse lobes; the upper leaves are pinnatifid with very fine divisions. The lower leaves of *Lepidium densiflorum* (common peppergrass) are pinnatifid or toothed; the upper ones are reduced, entire, or nearly so. In *Cardaria* (perennial peppergrass), *Thlaspi* (pennycress), *Lepidium campestre* (field peppergrass), *Neslia* (ball mustard), *Conringia* (hare's-ear-mustard), *Capsella* (shepherd's-purse), and *Camelina* (false flax), the rosette and lower stem leaves are petioled or narrowed at the base, while the middle and upper stem leaves are sessile with clasping basal lobes.

A host of well-known vegetable kinds are members of the mustard family, e.g. mustard, turnips, cabbage, cauliflower, Brussels sprouts. Some of them possess weedy forms and are not easily distinguished from related weeds. Such ornamentals as Alyssum, Iberis, and Stock are also of this group.

GENERA WITH YELLOW FLOWERS AND (USUALLY) ELONGATE, BEAN-POD-LIKE SILIQUES

Barbarea. Barbarea vulgaris, Yellow rocket, Winter cress. Perennial. p75
Plants with a conspicuous rosette of glossy leaves in fall and early

spring; blades pinnatifid with a large, rounded, terminal lobe. Stem leaves narrower, lobed or toothed. Flowers in dense racemes, yellow, but a richer or more orange tinge than mustards. Siliques elongate, crowded, usually ascending, tipped by a short beak. Seeds short-oblong, dull brown, narrowed and notched at one end. Spring. In eastern portion of range in grains and legumes; further west, primarily along roadsides and waste areas.

Brassica. Mustards. Plants annual or winter annual. Leaves not possessing rounded lobes. Flowers more of a lemon-yellow than *Barbarea*, less closely crowded. Pods with a long and distinctive beak.

Brassica kaber (Brassica arvensis), Wild mustard. Plants low and usually little branched, hairy. Siliques with short stalks
p76 which are nearly as thick as the pod proper, spreading in fruit. Seeds globular, smooth, black. Spring and early summer. Abundant in small grains and flax. Considered noxious in most states. The seeds are common in seed oats and flax.

Brassica juncea, Indian mustard. Plants sparsely hairy or glabrate. Siliques with slender pedicels which are much thin-
p77 ner than pod, spreading in fruit. Seeds subglobose, brownish, a little smaller than those of wild mustard, covered with a network of lines, red-brown in color. Early summer. Same areas as above but less common.

Brassica nigra, Black mustard. Plants hairy, frequently becoming tall and branched. Siliques short, upwardly directed, appressed against the stem. Seeds ellipsoidal or irregular in
p77 shape, covered with a very strong network of lines, red-brown in color. Fields, roadsides, and waste areas. Summer.

p78 *Camelina*, False flax. Leaves entire. Flowers yellow. Pods obovoid, somewhat flattened parallel to central partition. Three species, primarily in flax production areas.

p78 *Descurainia*, Tansy mustard, Flixweed. Two or three species with finely pinnatifid, fern-like leaves, yellow flowers, and oblong pods. Spring. Mostly roadsides and waste places, but also grassland and cultivated areas.

p79 *Conringia. Conringia orientalis*, Hare's-ear-mustard. Annual or winter annual. Leaves entire, mostly clasping. Flowers yellow. Siliques elongate, beakless. Rare except in northwestern portion of range. Spring.

p80 *Neslia. Neslia paniculata*, Ball mustard. Annual or winter annual. Stem leaves entire, clasping. Flowers yellow. Fruits ball-shaped, indehiscent, containing a single seed. Only locally common, grains and uncultivated land. Spring.

p78 *Raphanus. Raphanus raphanistrum*, Wild radish. Annual or winter annual. Pods elongate and beaked, constricted between the seeds, at maturity breaking into 1-seeded segments. Mostly northeastern, grains and waste areas.

Rorippa. *Rorippa islandica*, Marsh cress. Winter annual or biennial. p81 Leaves pinnatifid. Flowers yellow. Siliques pod-like, short. Seeds extremely small, about 0.5 mm. long. Low, poorly drained soils. Summer. Pods frequent in seed oats.

Sisymbrium. Leaves pinnatifid or lobed. Flowers yellow. Siliques pod-like, almost beakless.

Sisymbrium altissimum, Tumble mustard, Jim Hill mustard. Winter annual. Lower leaves coarsely pinnatifid; upper leaves divided into narrow thread-like segments. Pods long (exceeding 5 cm.) and narrow. p82 Seeds about 1 mm. long, short-oblong, with a longitudinal furrow on each side, light brown, similar to those of shepherd's-purse. Fields and waste areas, usually poor soil. Spring and early summer.

Sisymbrium officinale, Hedge mustard. Winter annual or annual. Lower leaves pinnatifid; upper blades commonly with p83 three narrow lobes. Siliques short, upwardly appressed against the flowering axis. Seeds 1.1-1.4 mm. long, often somewhat twisted, light yellow-brown to brownish-black, greasy in appearance. Pastures, legume seedings. Summer.

GENERA WITH WHITE FLOWERS AND SHORT SILIQUES

Berteroa. *Berteroa incana*, Hoary alyssum. Entire plant gray-hairy. p84 Leaves narrow, entire. Petals white, 2-lobed. Pods plump, ellipsoidal, beaked, hairy. Entire season. Most common in northern states. Grains, grassland, and waste ground.

Capsella. *Capsella bursa-pastoris*, Shepherd's-purse. Winter annual or annual. Leaves variously toothed or pinnatifid. Flowers white. Siliques short, flattened, triangular in shape. Seeds small, about 1 mm. long, p84 oblong, light brown, with a longitudinal furrow on each side. Cultivated ground, lawns, waste areas. Early spring, often very abundant.

Cardaria. *Cardaria draba (Lepidium draba)*, Perennial peppergrass, Whitetop, Hoary cress. Perennial from creeping roots. Plants closely p85 hairy. Flowers white, in dense racemes. Siliques short, heart-shaped, inflated, a distinct beak present at the apex, one seed in each chamber. Seeds about 2 mm. long, ellipsoidal, somewhat flattened, and not as thick as wide, narrowed towards one end; surface finely granular, red-brown in color; immature seeds occasionally drying brownish-black. Plants and the seeds of perennial peppergrass are sometimes confused with those of field peppergrass *(Lepidium campestre)*; note distinguishing silique and seed characters.

A weed of arid regions, of common occurrence only in western portion of our range, but declared primary noxious or prohibited in nearly all states. Where adapted, it will grow in almost any agricultural situation.

Perennial peppergrass grows actively in the spring and early summer. Following flowering it goes into a partial dormancy during the hot, dry portion of the season. In the fall it resumes growth, sending up new rosettes. Other closely related species and forms occur in the mountains and Pacific States.

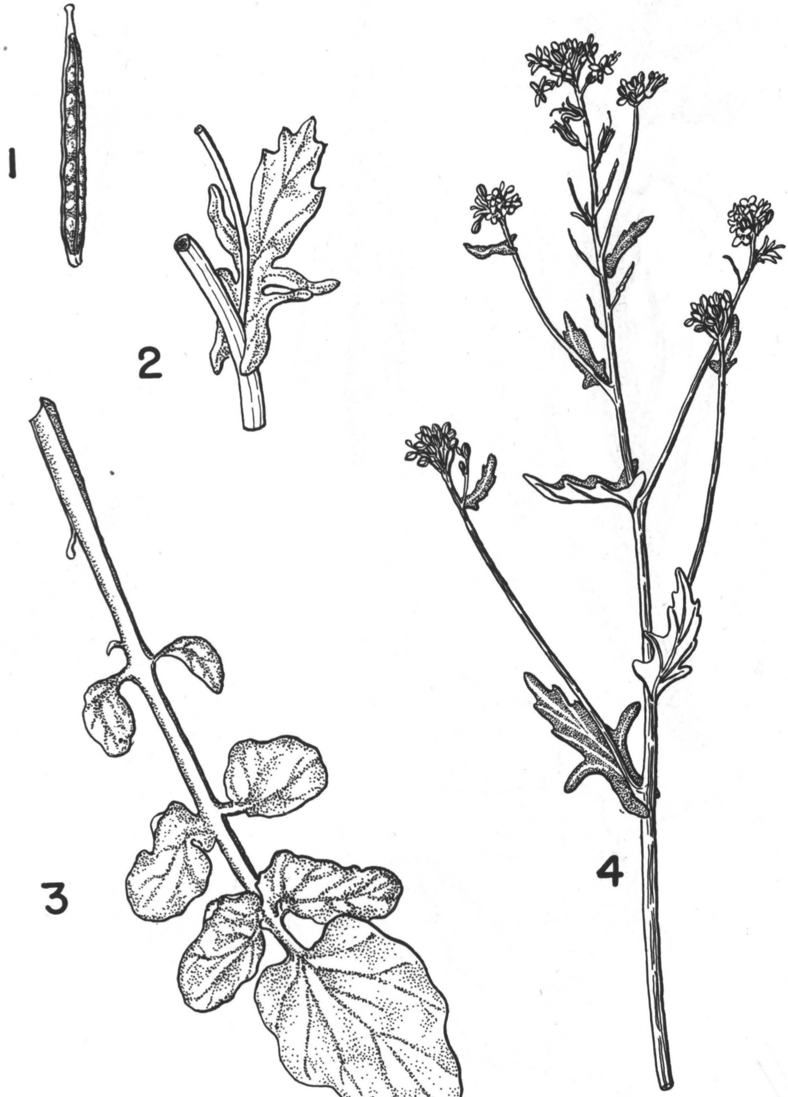
Lepidium, Peppergrass. Plants winter annual or annual. Flowers white (with petals) or greenish (petals lacking). Siliques short, elliptic in outline, notched at the apex without a beak, flat or inflated; internal partition placed at right angles to the plane of flattening, each chamber with one seed.

Lepidium densiflorum, Peppergrass, Green-flowered peppergrass. Basal leaves deeply pinnatifid. Petals absent, flowers p86 greenish. Siliques flat. Seeds 1.5-1.8 mm. long, obovate, flattened, narrowly winged, orange-brown in color. Fields, waste areas, and legume seedings. Early summer. Seeds found in red clover.

Lepidium virginicum, Peppergrass. Similar to above but with conspicuous white petals. This species, common in the eastern p86 United States, is frequently reported as a weed in the North Central States. However, most infestations seen are *Lepidium densiflorum*.

Lepidium campestre, Field peppergrass. Plants densely hairy. Leaves toothed, or the lower lobed. Siliques inflated on one p87 side, nearly flat on the other. Seeds 2.0-2.2 mm. long, obovoid (teardrop-shaped), brownish-black, nearly as thick as wide, rough-granular under magnification. Common, fields, roadsides, most common in central and eastern part of range. Spring.

Thlaspi. *Thlaspi arvense*, Pennycress, Fanweed, Frenchweed. Winter annual. Plants glabrous. Flowers white. Siliques flattened, similar in p87 appearance to those of common peppergrass but much larger, two or more seeds in each chamber. Seeds 1.7-1.9 mm. long, flattened, dark, the surface marked by very strong, curved ridges. Roadsides, small grains, waste areas. Spring. Less common to south and east.



Yellow Rocket

PLATE 29

Barbarea vulgaris 1. Mature silique x1 1/3. 2. Stem leaf x2/3. 3. Basal leaf x2/3. 4. Inflorescence x2/3.

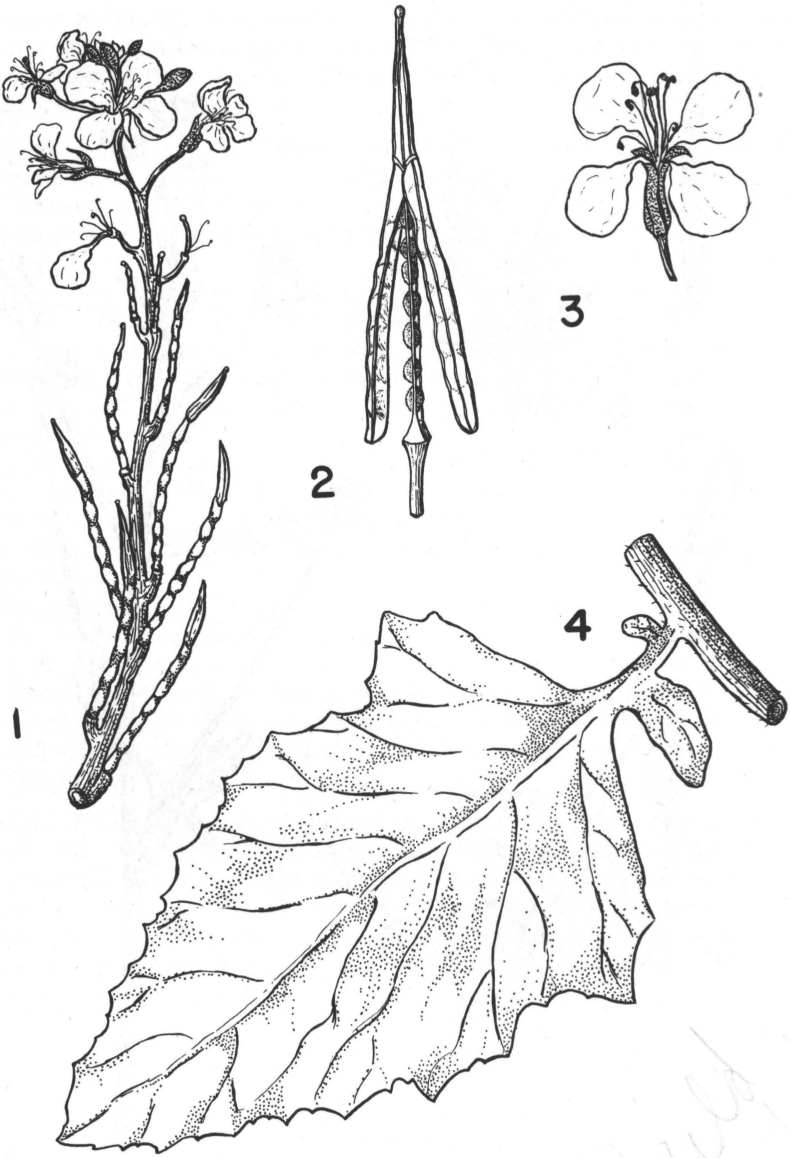


PLATE 30

Brassica kaber 1. Inflorescence x2/3. 2. Silique, valves partially separated, and seeds x1 1/3. 3. Flower x1 2/3. 4. Basal leaf x2/3.

PLATE 31

Brassica nigra 1. Mature inflorescence x2/3.
Brassica juncea 2. Siliques and basal leaf x2/3.

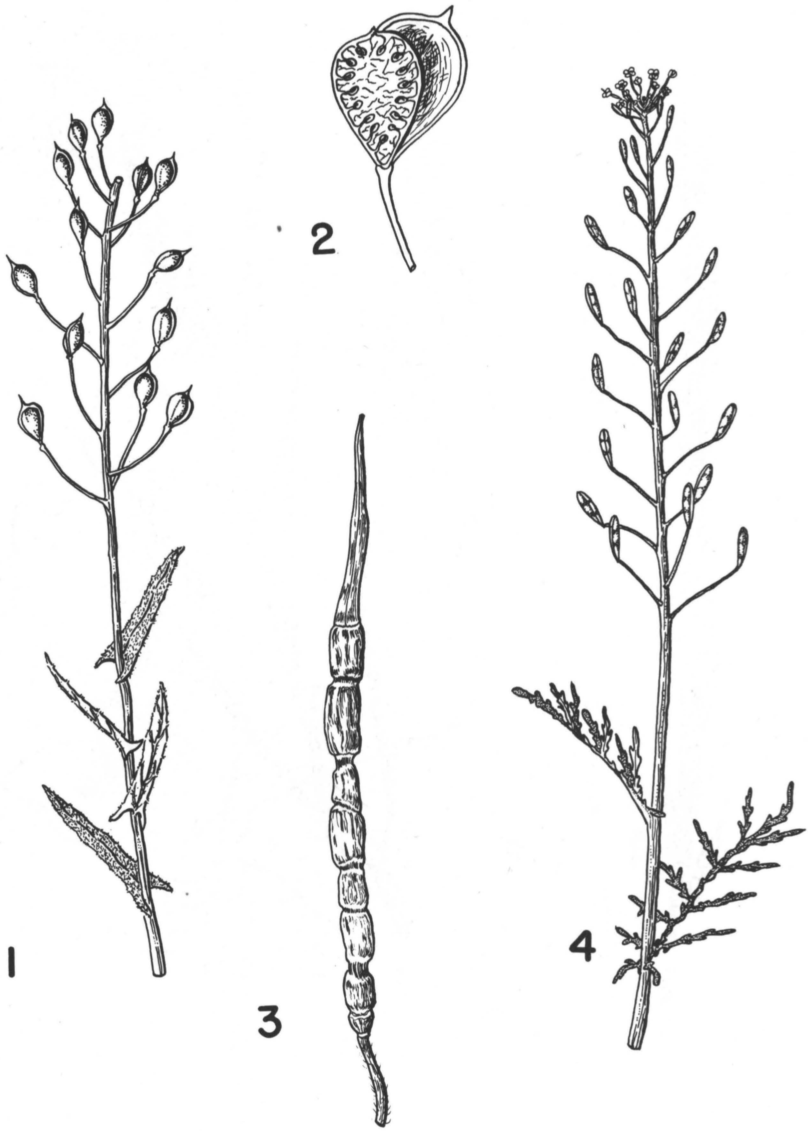


PLATE 32

Camelina microcarpa 1. Inflorescence x2/3. 2. Mature silique, seed bearing partition and one valve x4.
Raphanus raphanistrum 3. Silique x1 1/3.
Descurainia pinnata 4. Inflorescence x2/3.

PLATE 33
Conringia orientalis Habit x1/2.

PLATE 34

Neslia paniculata Habit x2/3.

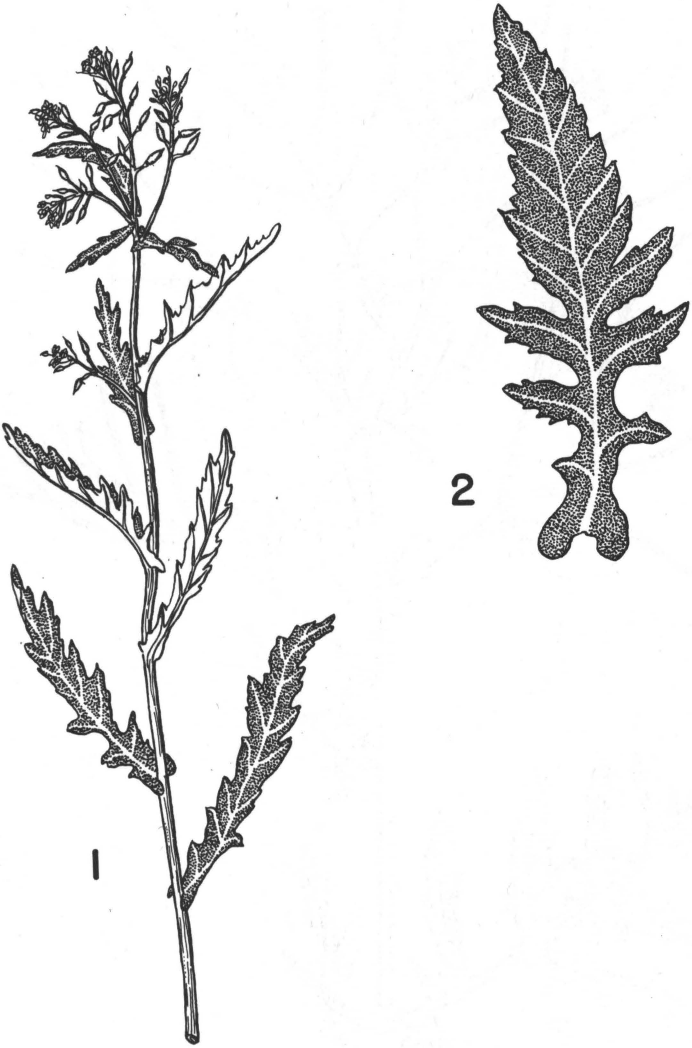


PLATE 35

Rorippa islandica 1. Apex of plant x2/3. 2. Basal leaf x2/3.

PLATE 36

Sisymbrium altissimum 1. Inflorescence x1/4. 2. Basal leaf x1/2.

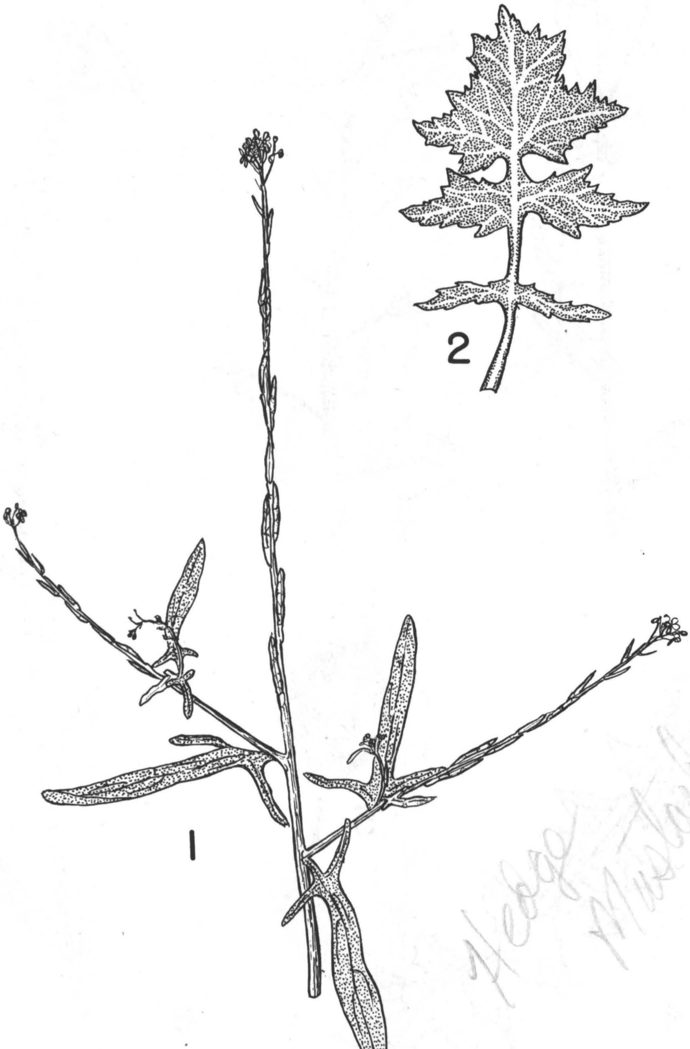
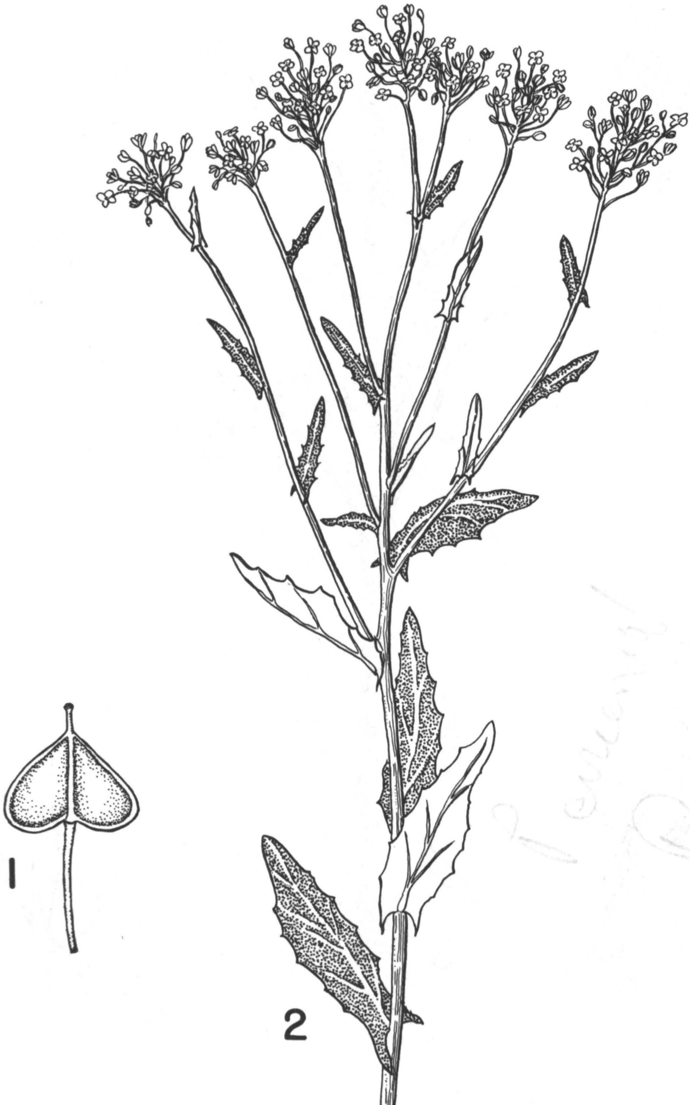


PLATE 37

Sisymbrium officinale 1. Inflorescence and upper leaves x2/3. 2. Basal leaf x2/3.

PLATE 38

Capsella bursa-pastoris 1. Silique x3. 2. Stem leaves x2/3. 3. Inflorescence x2/3. 4. Basal leaf x2/3.
Berteroa incana 5. Silique, one valve and seed-bearing partition x3. 6. Habit x2/3



Perennial Pepperweed

PLATE 39

Cardaria draba 1. Silique x3. 2. Habit x2/3.

PLATE 40

Lepidium virginicum 1. Flower x6.
Lepidium densiflorum 2. Basal leaf x2/3. 3. Habit x2/3. 4. Mature pod and seeds semi-diagrammatic x7.

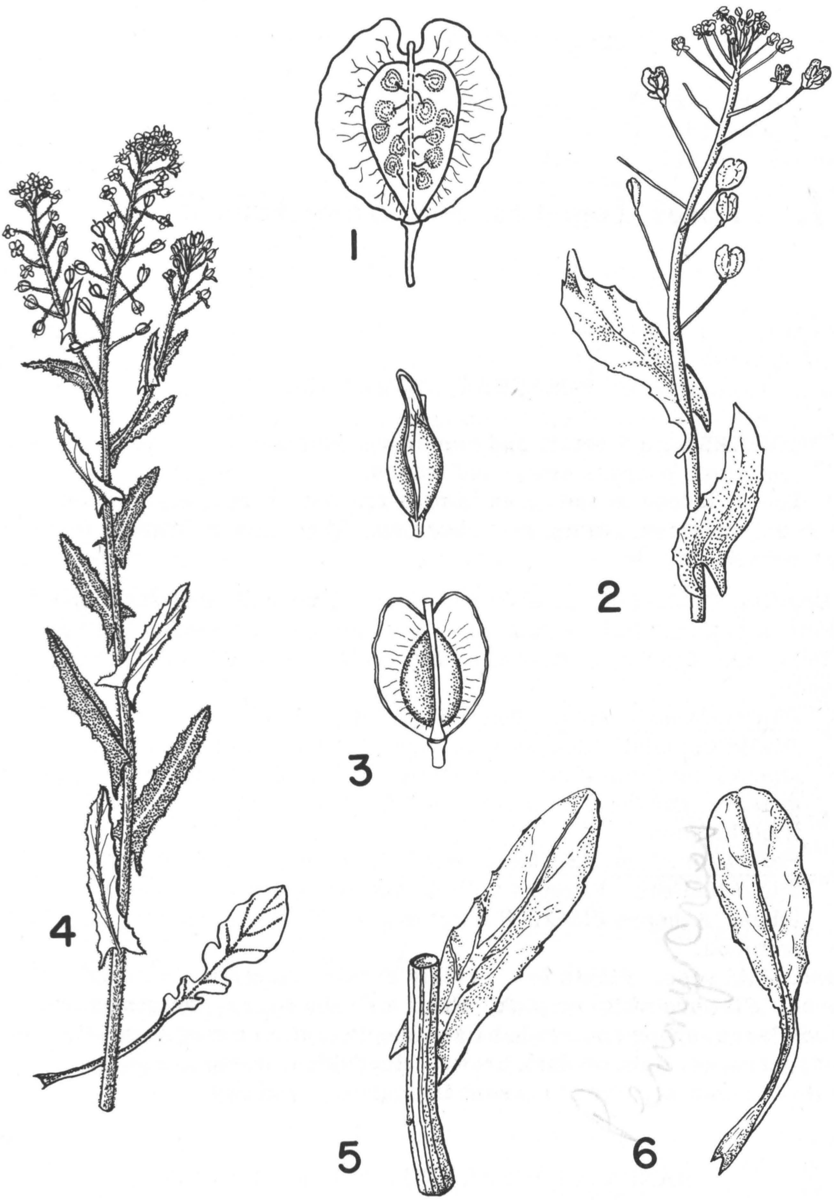


PLATE 41

Thlaspi arvense 1. Silique, semi-diagrammatic x2. 2. Inflorescence x2. 5. Middle stem leaf x2/3. 6. Basal leaf x2/3.
Lepidium campestre 3. Front and side view of pod x4. 4. Habit and basal leaf x2/3.

11. Roses, Legumes, and Other Families

ROSACEAE, ROSE FAMILY

FLOWERS with 5 petals and numerous stamens. Our weedy representatives possess compound leaves.

The Rosaceae include many important fruit crops, e.g. apples, peaches, cherries, plums, strawberries. There are relatively few weeds in the family.

Potentilla, Cinquefoil. Leaves palmately compound; leaflets toothed. Flowers yellow. Pistils numerous in each flower, ripening into achenes, 0.7-0.8 mm. across, flattened, semicircular, covered with curving ridges.

p92 *Potentilla norvegica*, Rough cinquefoil, Strawberry weed. Plants biennial. Leaves with three leaflets. Petals small, shorter than calyx lobes. Achenes brownish. Pastures, forage grasses, gardens. Summer. Seeds common in commercial timothy seed.

p92 *Potentilla recta*, Sulphur cinquefoil. Perennial. Leaves with 5 to 7 leaflets. Flowers with petals much exceeding calyx lobes. Achenes black. Habitat similar to above but less common.

p93 *Rosa*, Wild rose. Plants low, prickly shrubs. Leaves pinnately compound. Flowers white or pink. Fruit a fleshy berry-like structure. Seeds large, shaped somewhat like a section of an orange, smooth, bony in appearance, light or dark brown. Roadsides, waste areas, small grains. Summer. Seeds present in seed oats and rye.

RANUNCULACEAE, BUTTERCUP FAMILY

p94 *Ranunculus*, Buttercups. Flowers yellow, with numerous stamens and pistils. Leaves palmately dissected or lobed. Weeds mostly of wet pastures, ditches, and open woodland. Mostly of eastern states. Some species are poisonous to livestock.

PAPAVERACEAE, POPPY FAMILY

Argemone. Argemone polyanthemos (intermedia), Prickly poppy. Large annual with very prickly stems and leaves. Juice orange-colored. Flowers white, 1 dm. across. Fruit a many-seeded capsule. p95 Rangeland and uncultivated ground, southwestern part of area only.

LEGUMINOSAE, LEGUME FAMILY

Leaves alternate, compound with three leaflets, or pinnately compound. Stipules present. Flowers irregular with a large upper petal (standard), two side petals (wings), and two inner petals which are fused (keel) and enclose the pistil and stamens. Fruit a pod, 1-celled, several-seeded and dehiscent (e.g. bean pod), or 1-seeded and indehiscent (sweet clover).

The Leguminosae is a major economic family, possibly second only to the grasses. To it belong many of our major forage and soil conservation plants as well as kinds important for human food and industrial products. Contrariwise, it has but few weeds, none of especial significance in the North Central States. There are, however, some leguminous weeds in other parts of the United States. In the Southwest, especially western Texas, mesquite *(Prosopsis juliflora)*, a small leguminous tree, has invaded overgrazed rangeland. In many areas this mesquite forms almost solid stands; the cost of its eradication is a major problem in reclaiming the land. Camelthorn *(Alhagi camelorum)*,a thorny shrub, has been introduced in California and sporadically elsewhere. Because of its potential ability to invade grazing land, large sums of money have been spent in an attempt to eradicate it. Species of *Astragalus* (locoweed) and *Lupinus* (lupines) are important poisonous plants to stock in the western Great Plains and mountains.

The following primarily constitutes a review of important field crop legumes of the North Central States.

Glycyrrhiza. Glycyrrhiza lepidota, Wild licorice. Perennial with creeping rootstocks. Leaves with numerous leaflets. Flowers white. p96 Fruit spiny, cocklebur-like. Sporadic in prairie and plains states, most common West. Roadsides, pastures, ranges, usually wet land.

Lespedeza. Lespedeza stipulacea, Korean lespedeza. Annual. Plants semiprostrate or erect in dense stands. Stipules conspicuous, brown-membranous. Flowers axillary, lavender. Calyx persistent around p96 base of fruit. Pod ovoid, 1-seeded, short-pointed at the apex, brown, covered with a network of black lines. Seeds flattened-ellipsoidal, purplish-black, smooth and shiny. Grown in southern portion of range. Commercial seed may consist of seeds within the persistent pods, the hulled seeds, or a mixture of both.

Medicago, Alfalfa and related kinds. Terminal leaflet longer-stalked than lateral ones. Flowers in short spikes.

Medicago sativa, Alfalfa. Plants perennial. Stipules toothed, broader than in sweet clover. Leaflets toothed only on upper half. Flowers purple or varicolored, dull yellow to purplish. Pods several-seeded, spirally coiled, brownish. Seeds yel-
p97 lowish (turning orange-red with age), most commonly bean-shaped with the hilum on the side, but frequently irregularly ovoid,and similar to those of red clover or sweet clover. Distinguishing characters of doubtful alfalfa seeds: angular or lumpy, frequently pointed at end, longitudinal furrow not parallel to margin, seed coat not shiny. Grown for forage throughout range, often independently established along roadsides and waste places.

Medicago lupulina, Black medick, Yellow trefoil. Usually annual or biennial. Flowers yellow. Pods 1-seeded, black with
p97 curving lines. Seeds similar to those of alfalfa but shorter and with a distinct projection from middle of one side. Pastures, meadows, lawns, about buildings. Summer. More common in east. A weed with limited forage value.

Melilotus, Sweet clover. Plants biennial or annual, tall and branching. Stipules narrowly lanceolate, usually not toothed. Terminal leaflet longer-stalked than lateral ones; leaflets toothed along sides and at apex. Flowers in long spikes. Pod ovoid, one-seeded, indehiscent, light brown, covered with a network of lines or ridges. Seed flattened-ellipsoidal, only slightly notched or lobed (immature seeds may appear 2-lobed); longitudinal furrow directed nearly parallel to margin; surface dull yellow or yellowish-green (turning dull reddish-brown in age), not shiny. Common forage and green manure crop, also weedy along roadsides and waste areas.

Melilotus alba, White sweet clover, Hubam clover. Flowers
p97 white. Seeds not usually mottled. Pods with a coarse network of ridges.

Melilotus officinalis, Yellow sweet clover. Flowers yellow.
p97 Pods appearing cross-ribbed rather than net-nerved. Some of seeds (5 to 40 per cent usually) mottled with small dark dots.

p98 *Glycine. Glycine max,* Soybean. Plants annual, similar to the ordinary garden bean in general appearance. Flowers white to purple, in small axillary clusters. Pods flattened, hairy, 2- to 4-seeded. Seeds large, spheroid. Extensively cultivated.

Trifolium, Clover. Terminal leaflet not longer-stalked than lateral leaflets (compare with alfalfa and sweet clover). Flowers in spherical heads. Pods thin, one-seeded, enclosed within the withered corolla. Seed roughly rounded-ovoid in shape, usually distinctly 2-lobed or apically notched; hilum located at the "end" of the seed, or in a notch on the side; color various.

Trifolium hybridum, Alsike clover. Stems ascending or erect,
p99 nearly glabrous. Stipules broad, usually greenish. Heads on short stalks from leafy stems. Flowers white or pinkish.

Seeds smaller than those of red clover, sweet clover, or alfalfa, heart-shaped, greenish-black when mature, green or yellowish-green when immature. Cultivated, widely escaped, and to some extent weedy.

Trifolium pratense, Red clover. Biennial or short-lived perennial. Stems erect, hairy. Stipules large, hairy, nerved. Flower heads red. Seeds mitten-shaped, with a large terminal lobe and a shorter lateral one, yellow and purple mottled in p99 color, occasionally solid yellow or nearly solid purple-black; surface smooth and shiny. Widely cultivated and frequently escaped along roadsides.

Trifolium repens, White clover, Dutch clover, Ladino clover. Stems glabrous, prostrate, rooting at nodes. Leaves long petioled. Stipules at first greenish, soon becoming white-membranous. Flower heads on long, leafless stalks arising p100 directly from the prostrate stems. Flowers white. Seeds yellow (turning orange-red in age), heart-shaped, averaging slightly smaller than those of alsike, but otherwise essentially similar. Planted in pastures and lawns and much escaped.

Lotus. *Lotus corniculatus*, Birdsfoot trefoil. Plants perennial. Leaves p100 with 5 leaflets, the two lowest next to the stem and resembling stipules. Flowers yellow in stalked clusters. Pods several-seeded. Seeds irregularly rounded, brownish, frequently speckled. Cultivated, especially permanent pastures in southern part of area.

Vicia, Vetch. Leaves pinnately compound with several leaflets, termi- p100 nating in tendrils. Flowers purple, solitary in leaf axils or in racemes. Pods several-seeded. Seeds spheroid or lens-shaped. Several species; some essentially weeds; some cultivated, often escaped and growing as weeds. Mostly southern and western. As weeds, grain fields, and waste areas.

PLATE 42

Potentilla norvegica 1. Apex of plant x2/3. 2. Flower x1.
Potentilla recta 3. Leaf x2/3.

PLATE 43

Rosa sp. Flowering branch x2/3.

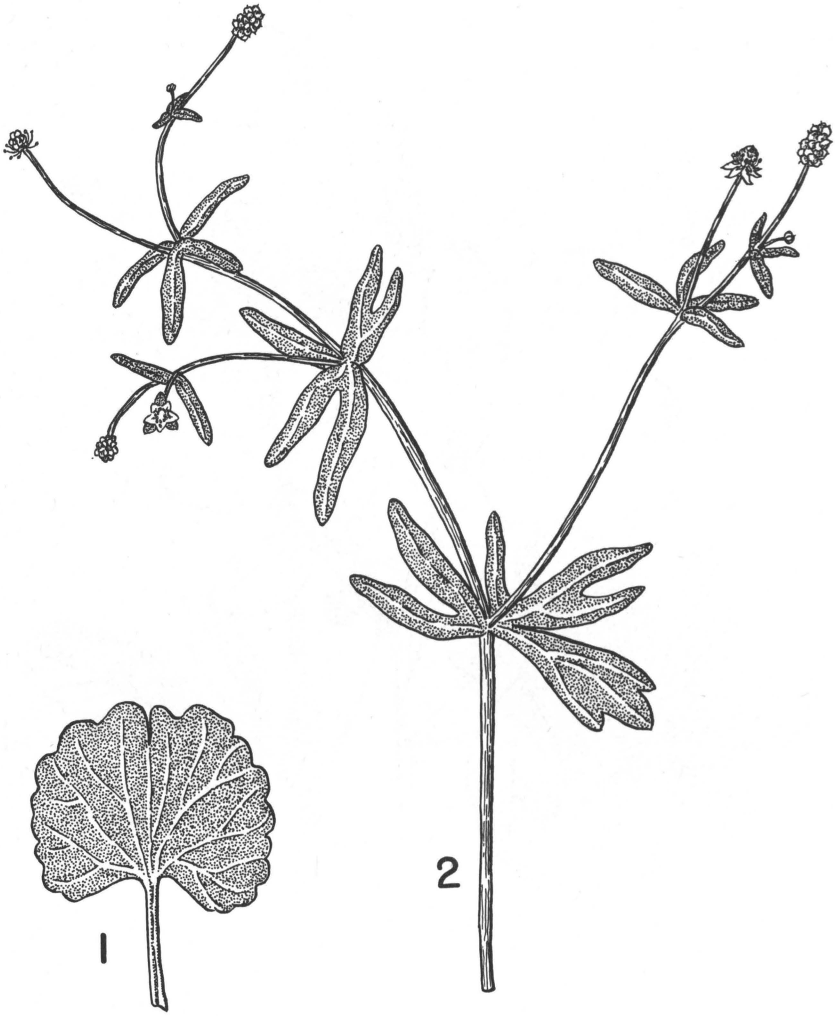


PLATE 44

Ranunculus abortivus 1. Basal leaf x2/3. 2. Apex of plant x2/3.

PLATE 45

Argemone polyanthemos 1. Fruit x2/3. 2. Flowering branch x2/3.

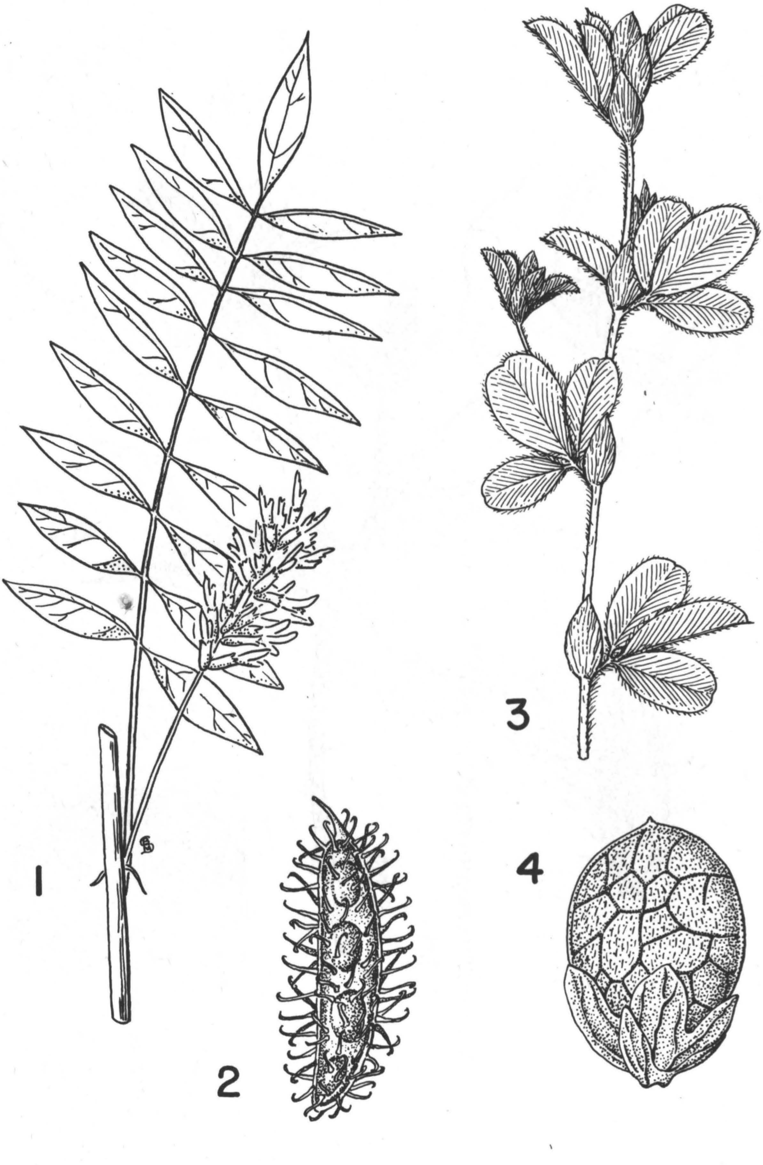


PLATE 46

Glycyrrhiza lepidota 1. Leaf and inflorescence x2/3. 2. Pod x2.
Lespedeza stipulacea 3. Habit x1 1/2. 4. Pod with investing calyx x10.

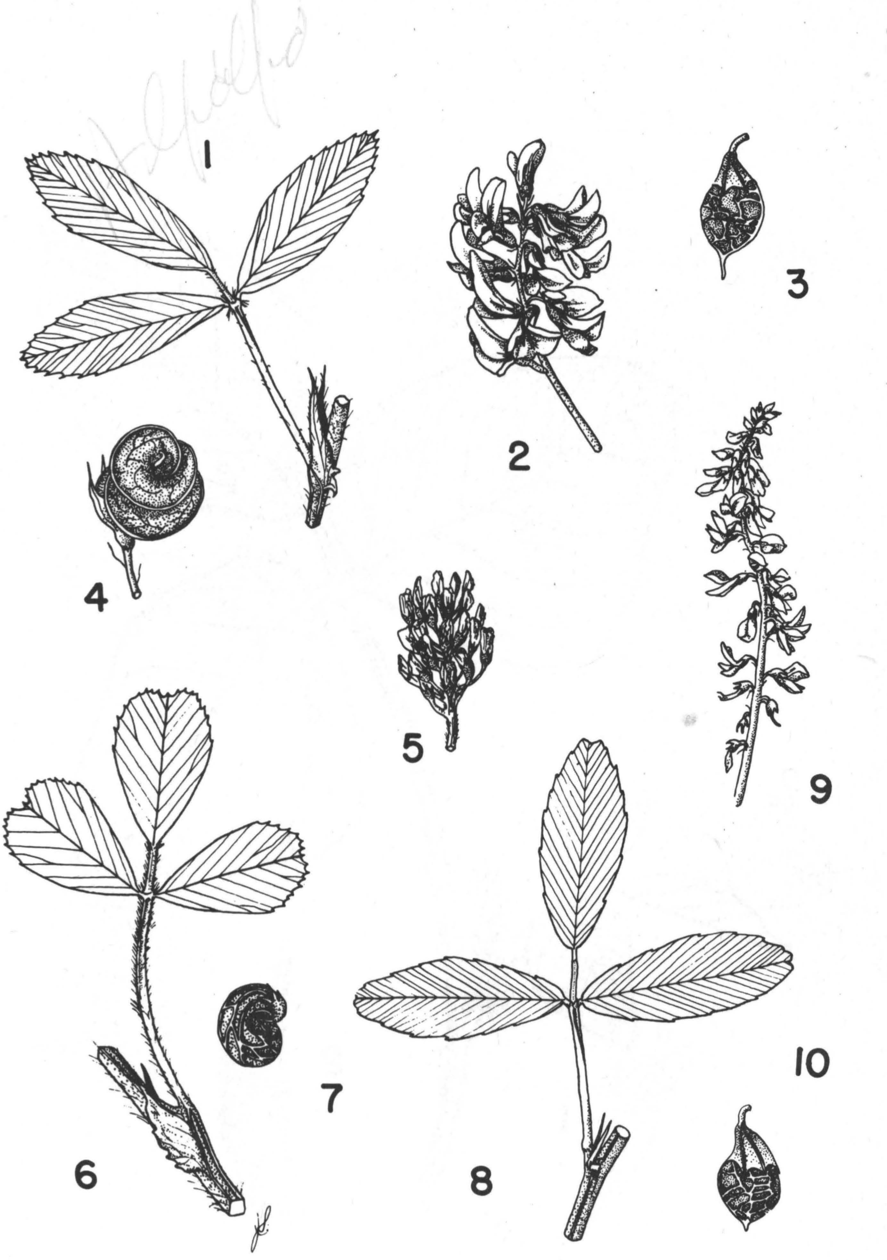


PLATE 47

Medicago sativa 1. Leaf and stipule x1 1/2. 2. Flower cluster x1 1/3. 4. Pod x2.
Medicago lupulina 5. Flower cluster x3. 6. Leaf and stipule x2. 7. Pod x5.
Melilotus alba 3. Pod x3.
Melilotus officinalis 8. Leaf and stipule x1 1/2. 9. Inflorescence fragment x1.
10. Pod x3.

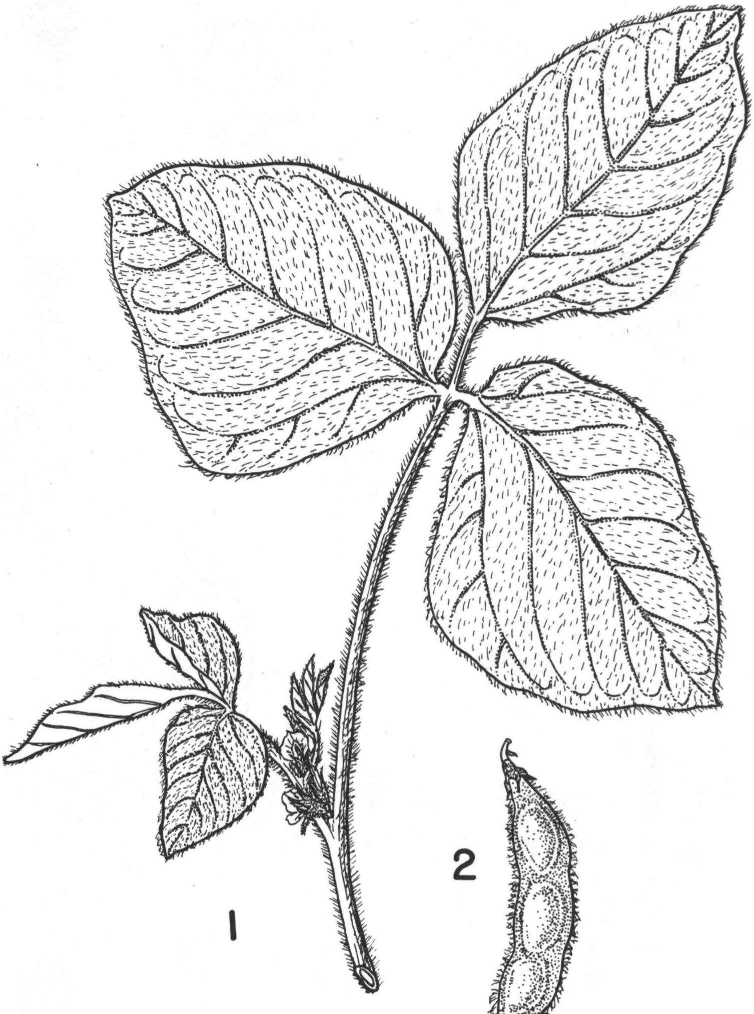


PLATE 48

Glycine max 1. Leaf x2/3. 2. Pod x2/3.

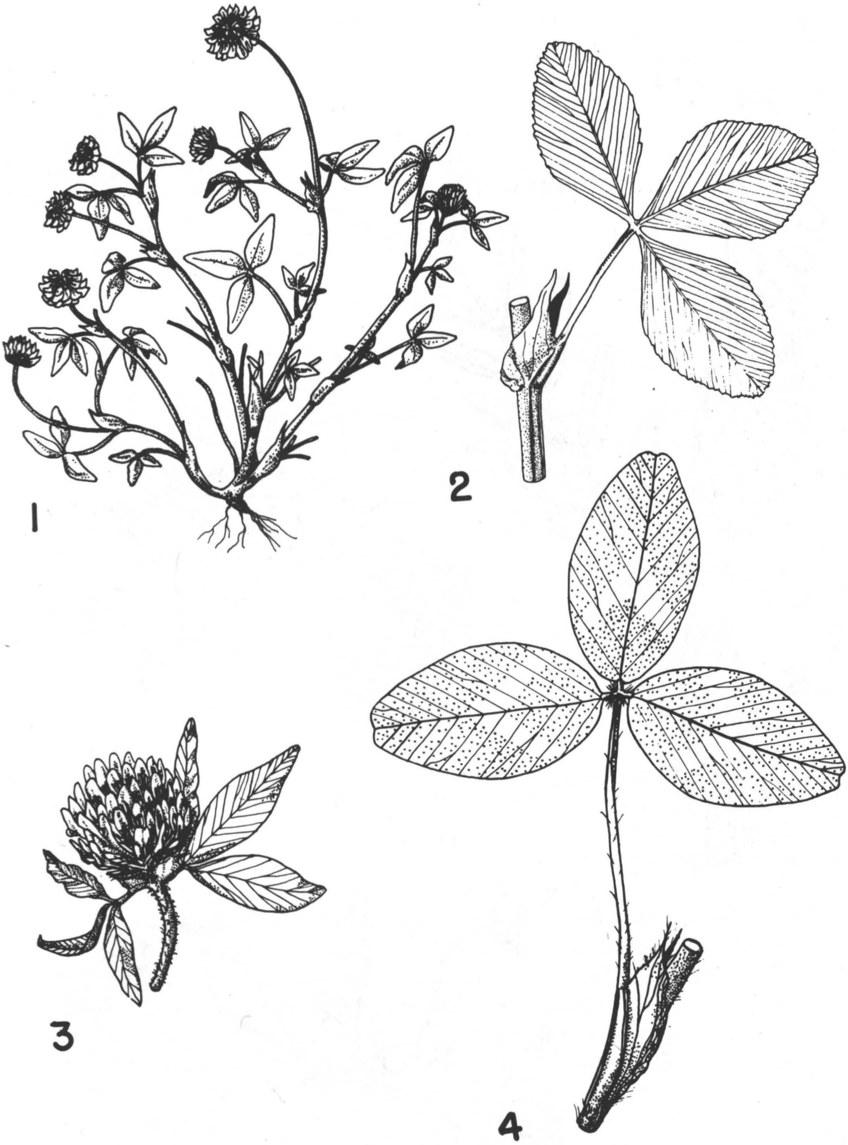


PLATE 49

Trifolium hybridum 1. Habit x1/3. 2. Leaf and stipule x1.
Trifolium pratense 3. Flower head x2/3. 4. Leaf and stipule x1.

PLATE 50

Vicia villosa 1. Inflorescence and leaf x2/3.
Lotus corniculatus 2. Flower cluster x2/3. 3. Leaf x1 1/3.
Trifolium repens 4. Flower head x1. 5. Habit x1/3.

12. Spurges and Related Families

EUPHORBIACEAE, SPURGE FAMILY

PLANTS DIVERSE as to vegetative characters. Common species with milky juice. Flowers much reduced, without petals, in some species with colored bracts (modified leaves) which resemble petals. Fruit usually a 3-lobed, 3-chambered capsule with one seed in each chamber. Seeds ellipsoidal, or short-oblong with a line or seam running from one end to the other; surface smooth or wrinkled.

Euphorbia, Spurges. Plants with milky juice. Fruit on a stalk which gradually elongates as it matures, the whole structure eventually hanging downwards out of flower cluster.

Euphorbia esula, Leafy spurge. Plant perennial from creeping roots. Stems densely leafy with entire, alternate, narrowly oblong blades which are 4-7 mm. wide. Flower clusters more or less umbellate, surrounded by yellowish-green bracts. Seed grayish (if slightly immature, brown-gray), smooth, and frequently shiny. A primary noxious or prohibited weed in most states. Most common in northern areas, otherwise sporadic in distribution. Late spring and early summer. p105

Nonflowering summer growth of this weed superficially resembles whorled milkweed *(Asclepias verticillata)*; the latter possesses considerably narrower leaves which are whorled rather than alternate (compare descriptions).

Euphorbia corollata, Flowering spurge. Perennial. Stems more sparsely leafy than leafy spurge, the blade ovate to lanceolate. Flowering bracts small, white, closely resembling petals. Seeds rough-whitish, with inconspicuous angles or ridges. Fields, roadsides, pastures. Midsummer. Mostly southern and eastern. p106

Euphorbia maculata (E. supina), Prostrate spurge. A much-branched prostrate annual with opposite leaves. Flower clusters axillary, inconspicuous. Seeds less than 1 mm. in length, irregularly short-oblong, finely pitted, gray to dull brown. Common in gardens, roadsides, waste areas. Summer. p107

Euphorbia nutans (E. maculata), Nodding spurge, Spotted spurge. Annual with branched, ascending or drooping stems. Leaves p108 opposite, similar to those of prostrate spurge but larger. Flowers in clusters near ends of branches. Seeds similar to those of prostrate spurge but larger, exceeding 1 mm. in length. Common in cultivated soil. Summer.

Euphorbia cyparissias, Cypress spurge. Similar to leafy
spurge but smaller in all parts. Leaves short, narrow, closely
p106 crowded. Sporadic, mostly Northeast. Waste ground, road-
sides, and cultivated as ornamental.

Euphorbia marginata, Snow-on-the-mountain. Annual. Leaves
mostly alternate, ovate to oblong, entire. Uppermost blades
p109 with conspicuous, whitish margins, whorled about flower clus-
ters. Southern and western. Summer. Pastures; in western
part of area, along roadsides or irrigation ditches; also culti-
vated as ornamental.

Acalypha. *Acalypha rhomboidea (A. virginica)*, Three-seeded mercury.
Annual. Juice scarcely milky. Leaves alternate, petioled, spatulate and
p110 somewhat toothed, often becoming bronze-colored in summer and with
conspicuous insect holes. Flowers axillary, subtended by palmately
lobed bracts. Mostly central and southern. Uncultivated areas and
around farmsteads. Summer.

Croton, Goatweed. Several annual species, usually with dense whitish,
p111 or rust-colored pubescence. Leaves alternate, petioled, serrate.
Flowers very inconspicuous, usually clustered at branch tips. Seeds
smooth, somewhat turtle-shaped. Exclusively southern. Pastures and
waste areas. Summer.

OXALIDACEAE, OXALIS FAMILY

Oxalis, Yellow sorrel. Low annuals or perennials. Leaves palmately
p112 trifoliate, the leaflets notched at apex. Flowers yellow, regular with
5 petals. Fruit an oblong, beaked capsule. Seeds numerous, flattened,
elliptic, conspicuously cross-ridged. Gardens (e.g. strawberry beds),
lawns, locally in truck crops. Summer.

ZYGOPHYLLACEAE, CALTROP FAMILY

Tribulus. *Tribulus terrestris*, Puncture vine. An annual, prostrate
p113 plant with pinnately compound leaves, small yellow flowers, and sharp
spiny burs. Primarily Southwest. A variety of habitats, most frequently
in dry, sandy, uncultivated soil. Summer. Considered secondary nox-
ious in several states.

GERANIACEAE, GERANIUM FAMILY

Geranium. Geranium carolinianium, Wild cranesbill. A low or bushy annual. Leaves alternate, palmately lobed or dissected. Flowers small with 5 pinkish petals. Fruit a long-beaked, 5-lobed capsule. Seed resembling that of a mustard, egg-shaped, the surface reticulate, a short seam along one end. Southern. A variety of habitats mostly in uncultivated ground. Summer. pl14

ANACARDIACEAE, CASHEW FAMILY

Rhus, Poison ivy, Sumac. Woody plants. Leaves pinnately compound. Fruits small, white or red drupelets.

Rhus toxicodendron, Poison ivy, Poison oak. Woody vines, low shrubs, or forming prostrate mats on the ground. Leaves alternate, trifoliate, the terminal leaflet stalked, the lateral ones sessile. Blades entire, toothed or irregularly lobed, dark green, commonly turning orange-red in late summer. Flowers greenish, in small axillary panicles. Fruit a white drupe-like structure with one seed. Common, fence rows, thickets, orchards, woodlands. Summer. pl15, pl16

Poison ivy is extremely variable as to habit and degree of toothing or lobing of the leaves. Some authors consider it to represent several closely related species.

Frequently, the general public asks how can one easily identify poison ivy, and be sure a mistake is not made. The simplest criterion is: if it is a woody plant with alternate leaves, each leaf with three leaflets, assume it is poison ivy. It is true that a few other (but relatively uncommon) woody plants will also fit the above diagnosis. However, attempts to distinguish between them and poison ivy will only complicate matters; the average person will do well to avoid them all as poison ivy.

The poisonous, dermatitis-causing principle in poison ivy is an oily substance. It is present in all parts of the plant — roots, stems, leaves, fruits. This material is not volatile; it will not be "blown" to a sensitive person who is in the vicinity but who does not actually contact the plant. On the other hand, the oil may be persistent on clothing, tools, the fur of pets, etc., if these have contacted the ivy. A sensitive individual may be poisoned by handling such objects or by welcoming the cocker spaniel back after a romp in the weeds.

The common, red-fruited sumacs treated below are not poisonous. Poison sumac is a white-fruited species which occurs in bogs and swamps, primarily in the eastern United States. It is of rare occurrence in the North Central States.

Rhus, Sumac. Small, brittle, zigzag-branched trees. Leaves pl17

pinnately compound with numerous leaflets. Flowers in a dense, branched cluster at stem tips, forming an assemblage of reddish drupelets, conspicuous in the fall. The leaves often turn red and orange in late summer, but well before frost. Pastures, usually hilly land, often poor quality or eroded soil, considered a "brushy weed."

RHAMNACEAE, BUCKTHORN FAMILY

Rhamnus. *Rhamnus cathartica*, Buckthorn. Small tree or large shrub. Leaves petioled, ovate, entire, glossy, alternate or clustered. Branch-
pl18 lets mostly terminating in thorns. Flowers clustered, small. Fruit
berry-like, black. Widely planted for hedging and windbreaks, also established in waste areas, along roadsides, *et al.*

Buckthorns are alternate hosts for crown rust of oats. For this reason they have been declared primary noxious weeds in Iowa, and their eradication is encouraged. Other species also occur in the North Central States but they are believed to be less important in transmitting crown rust.

BERBERIDACEAE, BARBERRY FAMILY

Berberis, Barberry. Shrubs with elliptic or ovate leaves and spines along the stems. Inner bark yellow. Flowers small. Fruits red berries.

Berberis vulgaris, Barberry. Leaves spiny-toothed. Thorns 3-forked. Berries in drooping clusters.

This plant is an alternate host of black stem rust of wheat. It was formerly rather common in the North Central States as a hedging shrub and abundantly escaped to waste areas. In 1918, a U. S.
pl19 Department of Agriculture Barberry Eradication Program was es-
tablished, and the plant has now been largely eliminated. It is sometimes confused with the Japanese barberry, described below, which is not a host for the rust.

Berberis thunbergii, Japanese barberry. Small shrubs. Leaves
pl19 entire. Thorns not branched. Berries usually in pairs, hanging
from leaf axils. A common ornamental for landscaping purposes, somewhat established independent of cultivation. Not a host for the rust.

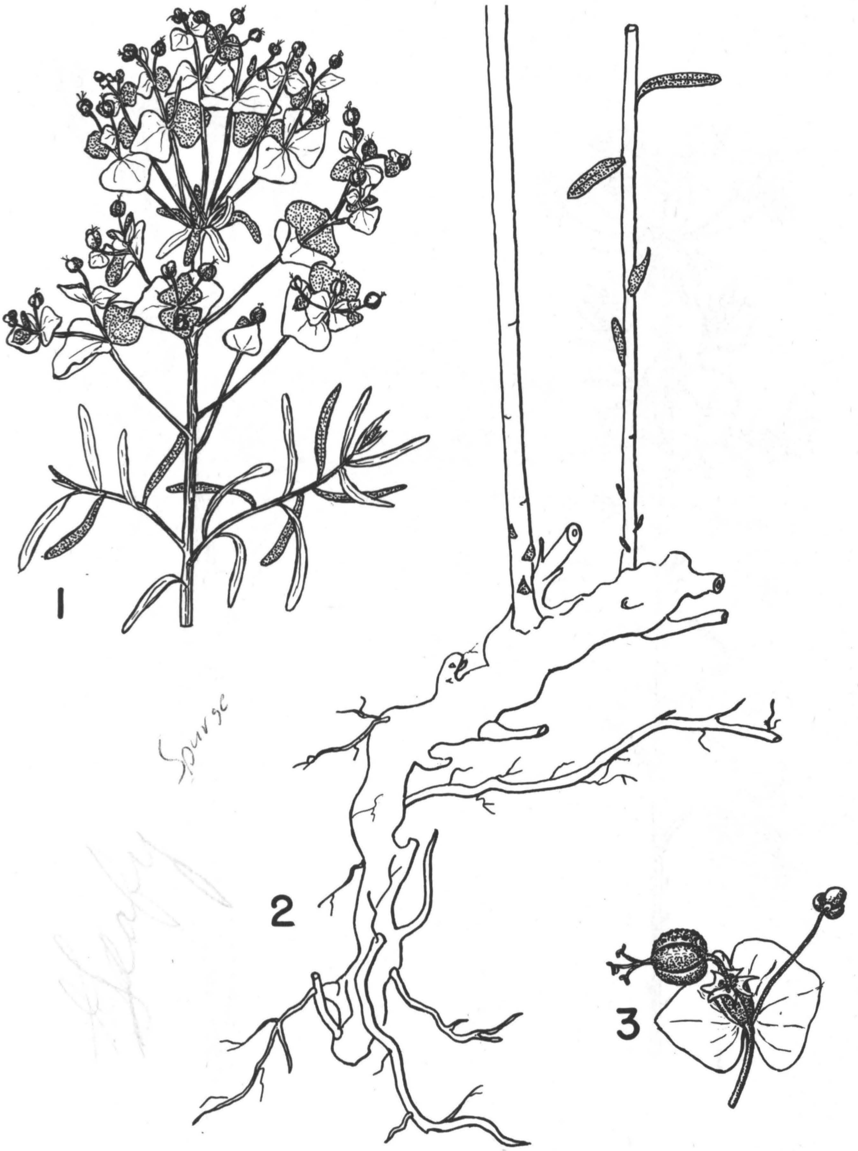


PLATE 51

Euphorbia esula 1. Apex of plant x1/2. 2. Perennial roots x2/3. 3. Fruits and subtending bracts x3.

PLATE 52

Euphorbia cyparissias 1. Habit x2/3.
Euphorbia corollata 2. Habit x2/3.

Prostrate

PLATE 53

Euphorbia maculata Habit x2/3.

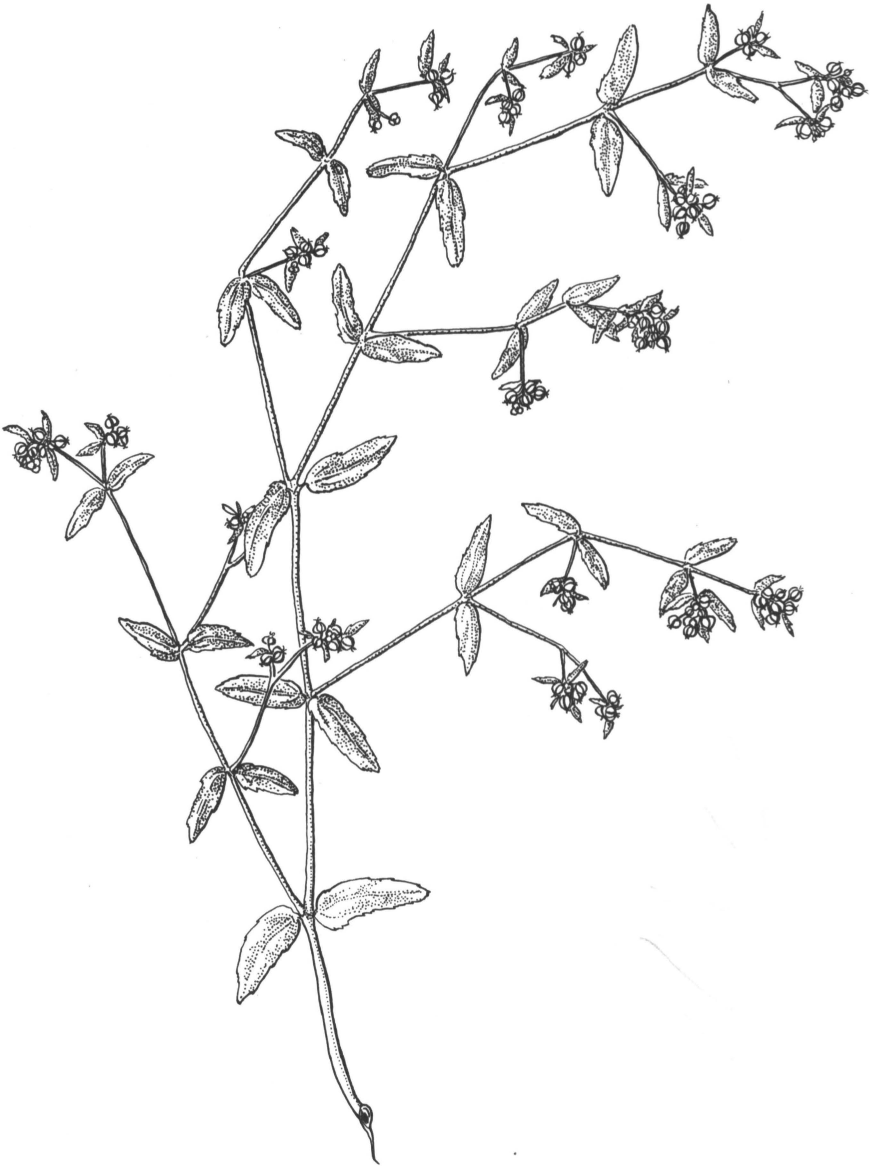


PLATE 54

Euphorbia nutans Habit x2/3.

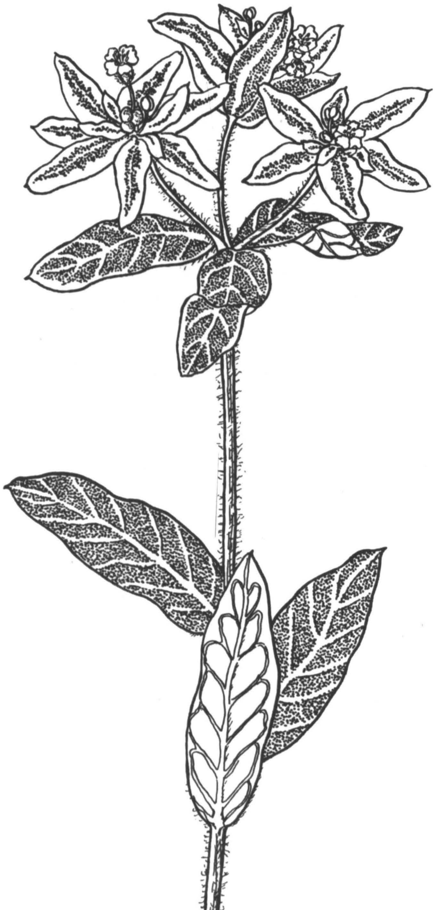


PLATE 55

Euphorbia marginata Habit x2/3.

PLATE 56

Acalypha rhomboidea Habit x2/3.

PLATE 57
Croton capitatus Habit x2/3.

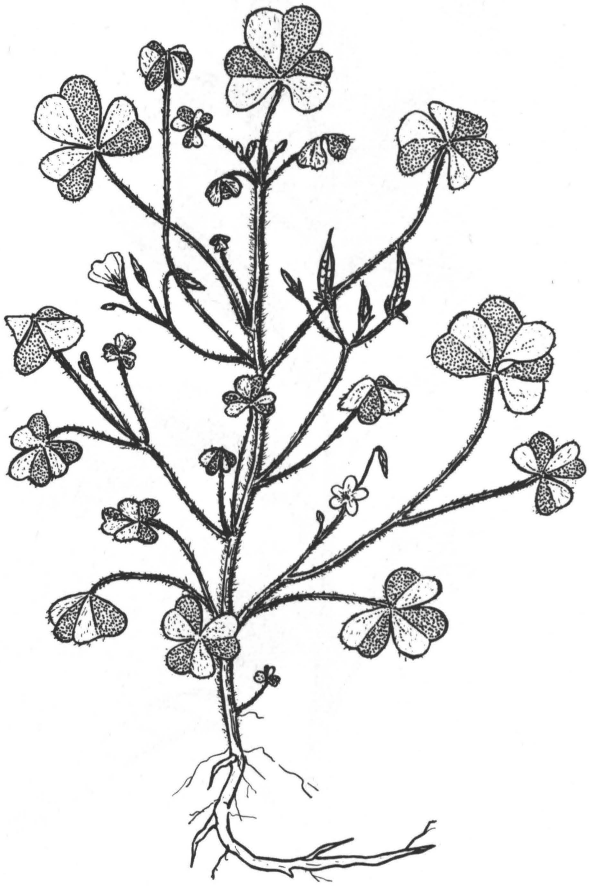
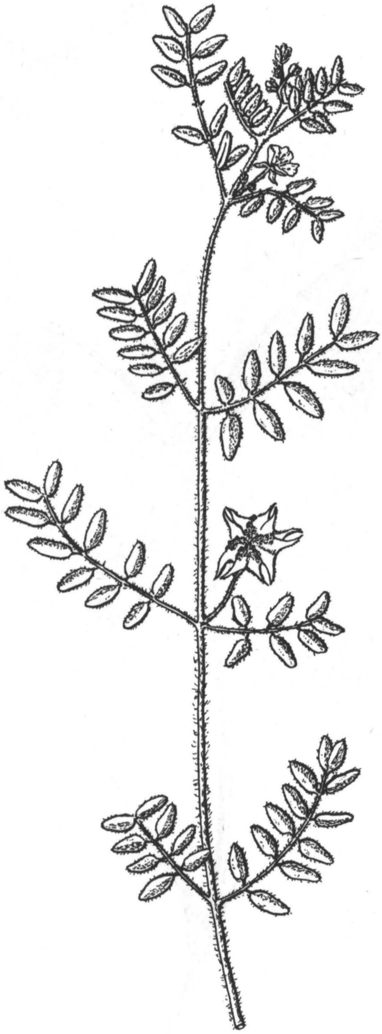


PLATE 58

Oxalis europaea Habit x2/3.



Puncture Vine

PLATE 59

Tribulus terrestris Habit x2/3.

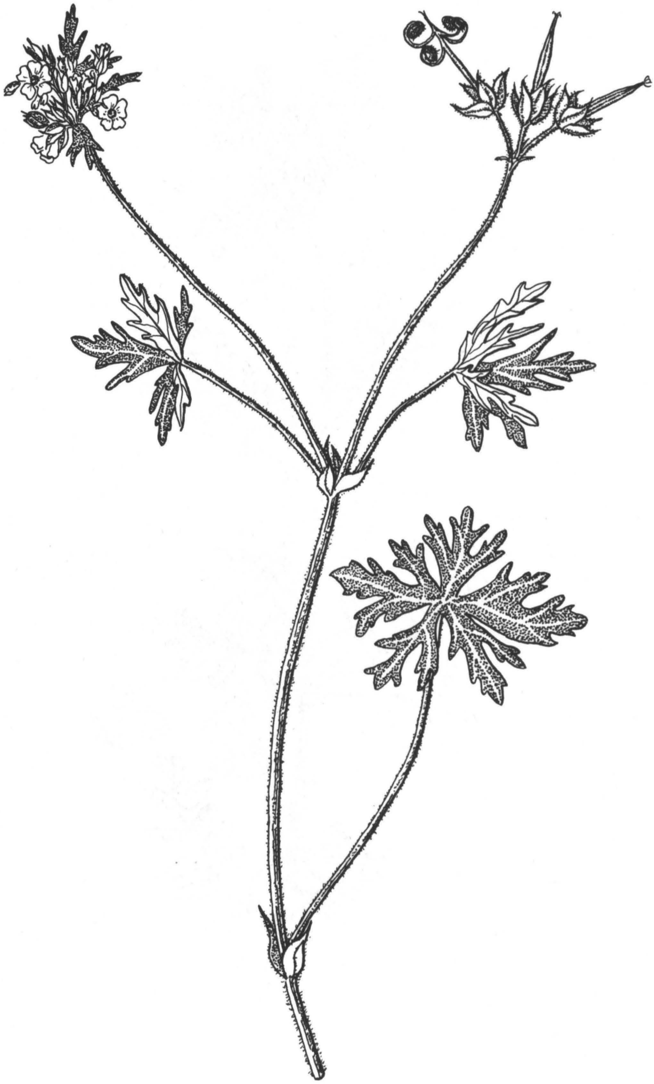


PLATE 60

Geranium carolinianum Habit x2/3.

Poison ivy

PLATE 61

Rhus toxicodendron Leaf and fruit x2/3.

PLATE 61-A

Rhus toxicodendron Variation in leaves x2/3.

PLATE 62

Rhus glabra Inflorescence and leaf x2/3.

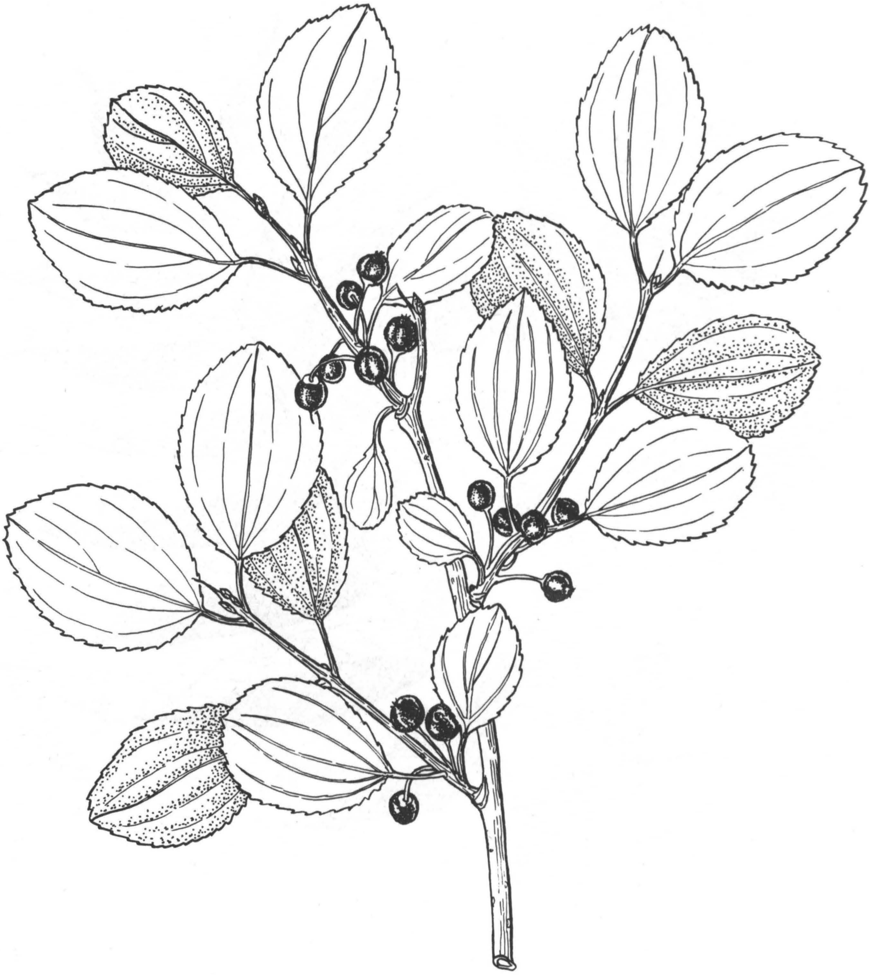


PLATE 63

Rhamnus cathartica Fruiting branch x2/3.

PLATE 64

Berberis vulgaris 1. Fruiting branch x2/3.
Berberis thunbergii 2. Flowering branch x2/3.

13. Mallows, Carrots, and Kin

MALVACEAE, MALLOW FAMILY

LEAVES ALTERNATE. Flowers with 5 petals and numerous stamens fused by their filaments into a column about the style. Fruit a several-chambered capsule, or breaking up into wedge-shaped segments. Seeds usually large with a hard, thick seed coat; embryo much folded or rolled within the seed; endosperm present.

Cotton (*Gossypium* spp.), one of the world's major economic plants, is a member of the mallow family. The group also contains okra and various ornamentals such as Althaea, Hollyhock, and Rose of Sharon.

Abutilon. Abutilon theophrasti, Butterprint, Velvet-leaf, Buttonweed.
Erect annual plants with velvety-hairy, cordate leaves. Flowers yellow-
pl22 orange. Fruit a capsule which splits from the top when mature. Seeds
large (3-4 mm. long), somewhat wedge-shaped, notched at narrow end,
dull gray-brown in color. Abundant, cultivated and waste ground. One
of the major annual weeds of corn and soybeans. Summer. Seeds common in soybean seed.

Hibiscus. Hibiscus trionum, Shoofly, Flower-of-an-hour, Venice mal-
low. Annual. Leaves irregularly palmately dissected or almost com-
pl23 pound. Petals yellowish-white with a purple center. Fruit a capsule
enclosed by the persistent membranous calyx. Seeds similar to those
of butterprint, but smaller, the surface covered with white scurfy markings. Locally abundant, gardens and cultivated fields. Summer.

Malva. Malva neglecta, Round-leaved mallow, Cheeses. Annual or win-
ter annual. Plants prostrate or spreading. Leaves long-petioled, cir-
pl24 cular in outline, with a deep notch at the base. Flowers axillary, white
or pinkish. Fruit wheel-shaped, radially splitting into wedge-shaped,
indehiscent, one-seeded segments. Seeds 1.4-1.6 mm. in diameter,
wedge-shaped, subcircular in face view, symmetrically notched at narrow end. Often abundant, moist soil, cultivated or more frequently uncultivated areas, around houses and farm lots.

pl25 *Sida. Sida spinosa,* Prickly sida. Annual. Leaves narrowly ovate, serrate. Flowers small, yellow, axillary. Fruit splitting into 5 pieces (like sections of an orange), each 1-seeded, and tipped with a pair of spines. Exclusively southern, a variety of habitats. Summer.

LINACEAE, FLAX FAMILY

Linum usitatissimum, Flax. Plants annual, erect, closely leafy with linear-lanceolate blades. Flowers showy, blue. Fruit a capsule. Seeds about 5 mm. in length, flattened, irregularly ovate in face view, brown, p125
the surface smooth and oily in appearance. A crop, occasionally escaped.

ONAGRACEAE, EVENING-PRIMROSE FAMILY

Sepals and petals produced at the apex of a tube which extends well above the ovary (ovary inferior). Sepals 4, petals 4, stamens 8. In addition to the following, a number of other members of this family occur as weeds in the North Central States and elsewhere in the country.

Oenothera. *Oenothera biennis*, Evening-primrose. Plants biennial. Stems erect, mostly unbranched, hairy, closely leafy. Leaves sessile, lanceolate, irregularly toothed. Flowers terminally spiked, yellow, the p126
sepals and petals raised above the ovary on a long tube. Fruit a 4-angled, 4-chambered capsule. Seeds small (slightly over 1 mm. in length), polyhedral or brick-like in shape, dusty-red in color. Fields, pastures, roadsides. Summer. Seeds occasional in clover seed.

UMBELLIFERAE, CARROT FAMILY

Leaves compound. Flowers in compound umbels, usually small, white or yellow. Fruit at maturity splitting longitudinally into two seed-like one-seeded segments (mericarps). "Seeds" (the mericarps) commonly plano-convex, usually possessing longitudinal ribs on the curved surface.

Daucus. *Daucus carota*, Wild carrot. Biennial. Leaves "fern-like" in appearance, the leaflets dissected or compound. Umbels subtended by pinnatifid bracts. Flowers white. "Seeds" 2.5 mm. long with rows of p127
bristles arising from longitudinal ribs. More common eastward, pastures, meadows, roadsides. Summer. Seeds stripped of bristles are occasional in legume seed.

Cicuta maculata, Water hemlock. Plants perennial from clusters of thick, spindle-shaped roots. Leaflets lanceolate, toothed, much broader than those of wild carrot. Flowers white. Seeds without bristles, possessing wide, dark-colored longitudinal ribs. Locally abundant in wet p128
pastures and roadside ditches. Summer. The roots are poisonous.

Pastinaca sativa, Wild parsnip. Plants biennial. Leaflets broad, irregularly toothed or lobed. Flowers yellow. Seeds elliptic in outline, about 5 mm. in length, flattened, light brown in color. Common, roadsides, p129
fence rows, thickets. Early summer.

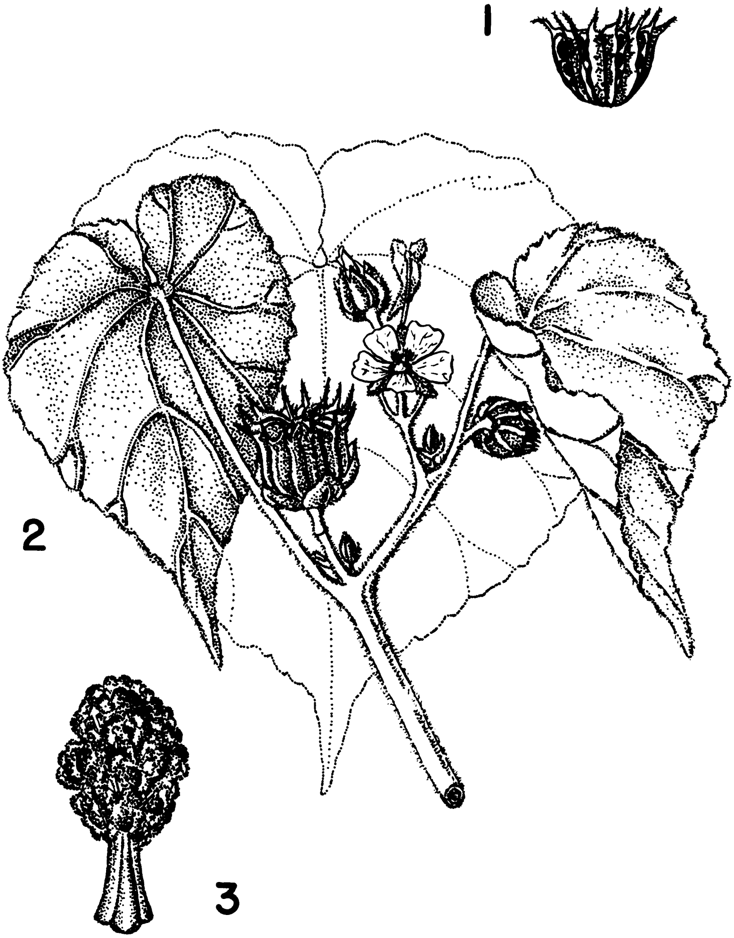


PLATE 65

Abutilon theophrasti 1. Fruit x2/3. 2. Flowering branch x2/3. 3. Stamen cluster x2.

PLATE 66
Hibiscus trionum Habit x2/3.

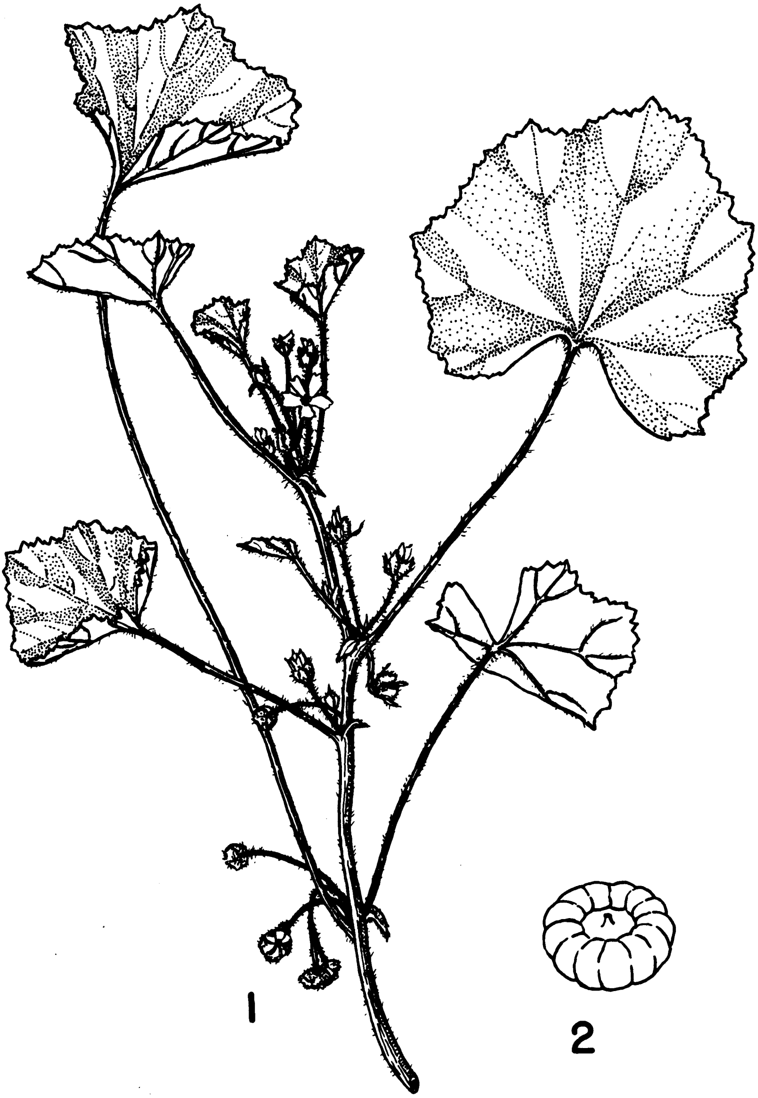


PLATE 67

Malva neglecta 1. Habit x2/3. 2. Fruit, semi-diagrammatic x2 1/2.

PLATE 68

Sida spinosa 1. Habit x2/3.
Linum uisitatissimum 2. Habit x2/3.

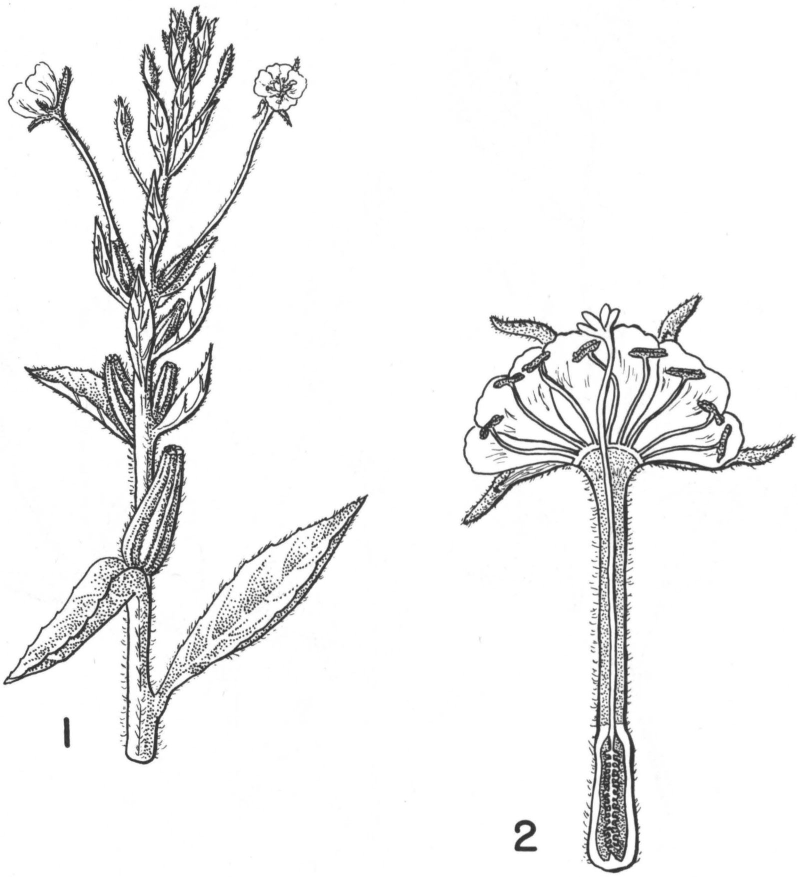


PLATE 69

Oenothera biennis 1. Habit x2/3. 2. Flower, semi-diagrammatic x2 1/2.

PLATE 70

Daucus carota 1. Leaf x1/3. 2. Mericarp halves of fruit x4. Inflorescence x1/2.

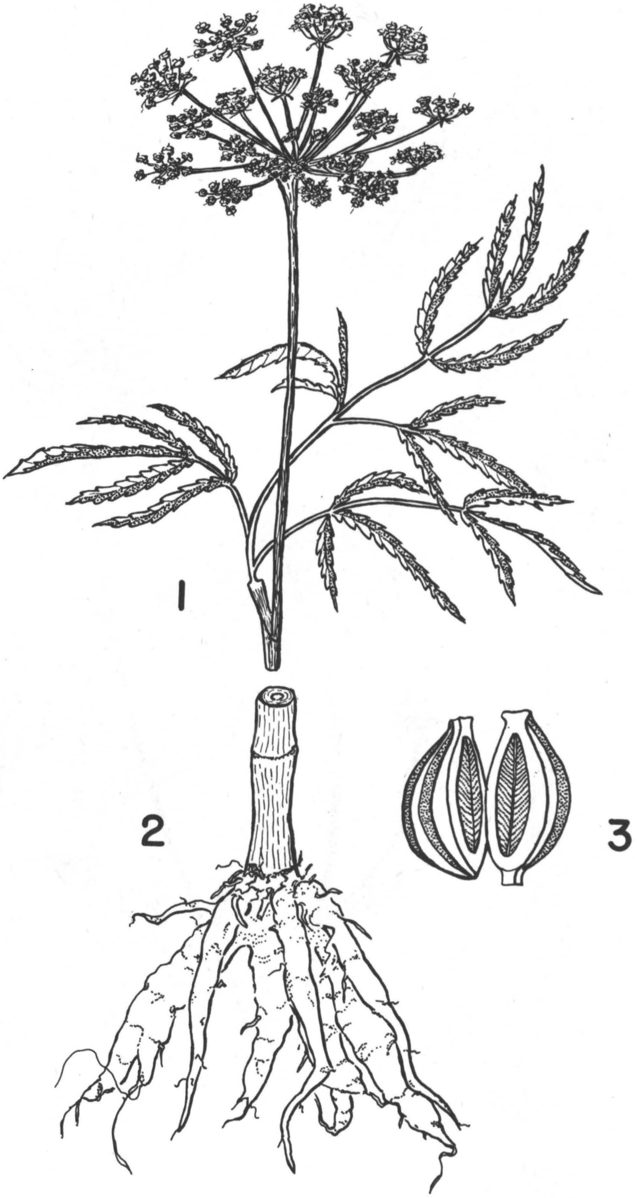


PLATE 71

Cicuta maculata 1. Inflorescence and leaf x1/2. 2. Root cluster x2/3. 3. Mericarp pair x5.

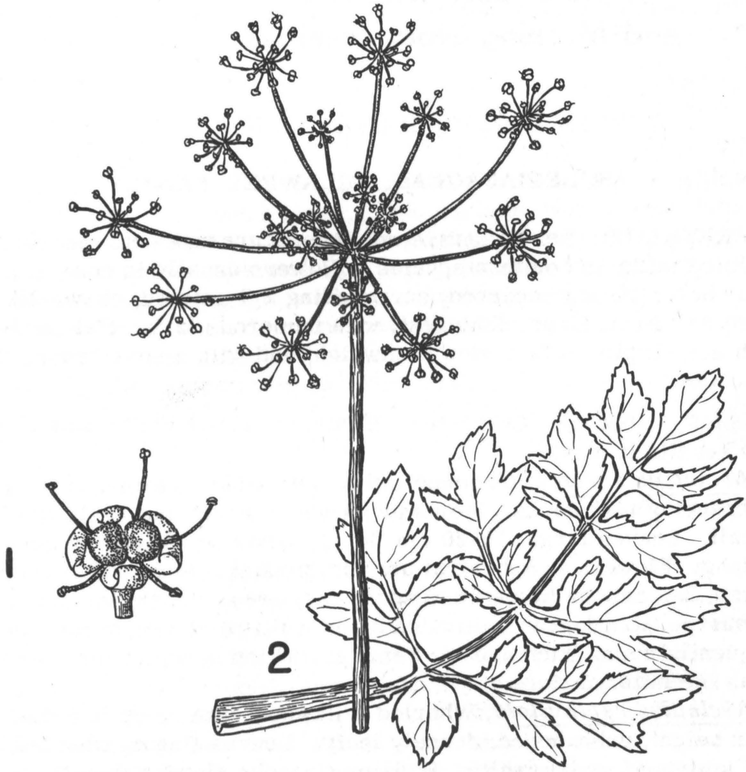


PLATE 72

Pastinaca sativa 1. Flower x4. 2. Inflorescence and leaf x2/3.

14. The Milkweed, Dogbane, and Morning-Glory Families

ASCLEPIADACEAE, MILKWEED FAMILY

PERENNIALS. Leaves entire, various in arrangement and shape. Juice milky in common species. Flowers usually in conspicuous umbels. Petals recurved, surrounding a 5-pointed, crown-like structure. Fruit large, dehiscent, with numerous large, flat seeds which are elliptic in face view, brownish, and with a conspicuous tuft of long hairs.

Asclepias, Milkweed. Characters of family. Erect plants with essentially sessile leaves.

p133 *Asclepias syriaca*, Common milkweed. Plants perennial from creeping rootstocks. Stems unbranched, becoming 10-12 dm. tall. Leaves large (15-20 cm. long), opposite, elliptic to oblong. Flowers in spherical umbels, pinkish. Pods soft, greenish, 2-3 cm. in diameter at base, narrowed at apex, the surface warty. Abundant in cultivated and uncultivated soil, most frequently moist, rich areas. Summer. Often conspicuous in oats as the latter mature.

p134 *Asclepias verticillata*, Whorled milkweed. Stems up to 5 dm. in height, unbranched, densely leafy. Leaves linear, whorled. Flowers greenish-white. Pods much more slender than those of common milkweed. Abundant, roadsides, pastures, fields. Summer.

p135 *Asclepias tuberosa*, Butterfly-weed. Leaves alternate, narrowly oblong. Juice not milky. Flowers orange. Southern. Pastures. Summer.

p136 *Ampelamus*. *Ampelamus albidus*, Climbing milkweed. Plants perennial, twining. Leaves opposite, petioled, cordate. Flowers greenish-white, in axillary clusters. Southern. Locally common, fence rows and fields. Summer.

The vegetative appearance of this plant (leaves and habit) is similar to that of the bindweeds *(Convolvulus)*, morning-glories *(Ipomoea)*, and wild buckwheat *(Polygonum convolvulus)*. These plants all have alternate leaves; the milkweed possesses opposite blades.

APOCYNACEAE, DOGBANE FAMILY

Apocynum. *Apocynum sibericum*, Dogbane, Indian hemp. Perennial from creeping rootstocks, erect, branched, with milky juice. Leaves opposite, entire, oblong, nearly sessile. Flowers small, borne in clusters amidst the foliage, whitish. Fruits pod-like, slender, and pointed. Seeds small, oblong, each with a long tuft of fine hairs. Uncultivated areas or low, cultivated soil. More common Southeast. p137

CONVOLVULACEAE, MORNING GLORY FAMILY

Plants viny, trailing or twining. Leaves alternate, entire, with a pair of basal lobes. Flowers large, gamopetalous, with a basal tube and a spreading limb. Fruit a two-chambered capsule containing 2 to 5 seeds in each chamber. Seeds large, irregularly wedge-shaped or nearly spheroid; hilum large; embryo convoluted within seed.

The above description does not entirely apply to the parasitic genus *Cuscuta*, which is characterized below.

In all families prior to this one, the petals present were essentially separate one from another. In this and following families, the petals, if present, are fused into a single corolla unit and said to be gamopetalous.

Convolvulus, Bindweed. Plants perennial from creeping roots or rootstocks. Basal lobes of leaves (in our species) pointed, sagittate or hastate. Stigmas two.

Convolvulus arvensis, Field bindweed, Creeping jenny, European bindweed. Plants perennial from creeping roots. Stems usually spreading on the ground, occasionally twining. Leaves commonly oblong-ovate with downwardly directed basal lobes. Leaf blade usually continuing in essentially a straight line in relation to the petiole. Flowers about 2 cm. across, light pink or white. Pedicels with a pair of small bracts well below the flower. Seeds 3-4 mm. long, irregularly obovoid with a thick, heavy coat; surface grayish, roughened by low, irregularly curving ridges. One of the most feared noxious weeds in the North Central States, most abundant and of greater consequence in the more arid western tier of states. All habitats, persisting under cultivation Summer. p138

When in flower, this plant is easy to distinguish from hedge bindweed, described below, because of the closely bracted, much larger flower of the latter. The two are sometimes confused previous to flowering. While the leaves are different, those of the field bindweed averaging smaller, having less of a pointed shape, and narrower basal lobes than those of hedge bindweed, too much reliance cannot be placed on leaf shape alone. The leaves of field bindweed are extremely variable in form, ranging from those which are broad and lush to narrowly oblong kinds with minute basal lobes. Greater consideration should be given to the habit of the plant and the position of the blades relative to the petiole; those of field bindweed usually continue in the same direction, while those of hedge bindweed usually curve nearly at right angles to the petiole. Both of these plants are sometimes confused with wild buckwheat *(Polygonum convolvulus)*; distinctions have been discussed under the latter species.

p138 *Convolvulus sepium*, Hedge bindweed. Plants perennial from creeping rootstocks, twining or climbing if support is available, otherwise spreading on the ground. Leaves triangular-ovate, pointed at apex, curved at right angles to the petiole. Flowers white to pink, 4-5 cm. wide, the calyx subtended by a pair of large bracts. Seeds obovoid, wedge-shaped, larger than those of field bindweed, the surface black, relatively smooth, hilum conspicuous, reddish-margined. Widely distributed but most common and important as a weed in the eastern more humid portions of the North Central States, infrequent in the western tier. A variety of habitats, both cultivated and uncultivated soil. Summer.

Ipomoea, Morning-glory. Our species annual. Leaves cordate with rounded basal lobes or 3- to 5-lobed. Flowers white, purple, or blue. Style one; stigma capitate. The sweet potato is a perennial species of *Ipomoea*.

p139 *Ipomoea purpurea*, Morning-glory. Leaves cordate. Cultivated crops, corn and soybeans, and waste areas. Predominately southern. Summer. Seeds occur in those of soybeans.

p139 *Ipomoea hederacea*, Ivy-leaved morning-glory. As above, but leaves palmately lobed.

p140 *Cuscuta*, Dodder. Plants parasitic, the plant body consisting of a twining mass of yellow, thread-like stems which send suckers into the stem of the host plant. Flowers small, whitish, produced in dense masses. Seeds much smaller than those of *Ipomoea* and *Convolvulus*, spheroid, or irregularly wedge-shaped; seed coat brownish-gray with a sandpaper-like texture. Secondary or restricted noxious in all seed laws. Throughout region in legumes and flax, but only locally abundant.

Dodder causes the greatest amount of damage to lespedeza and is much feared in the southeastern United States where lespedeza is an important forage and soil improvement plant. Dodder may also be harmful to alfalfa; it is less common in red clover. Dodder seeds are disseminated in agricultural seed and in hay. The seeds are hard and capable of living in the soil for a number of years.

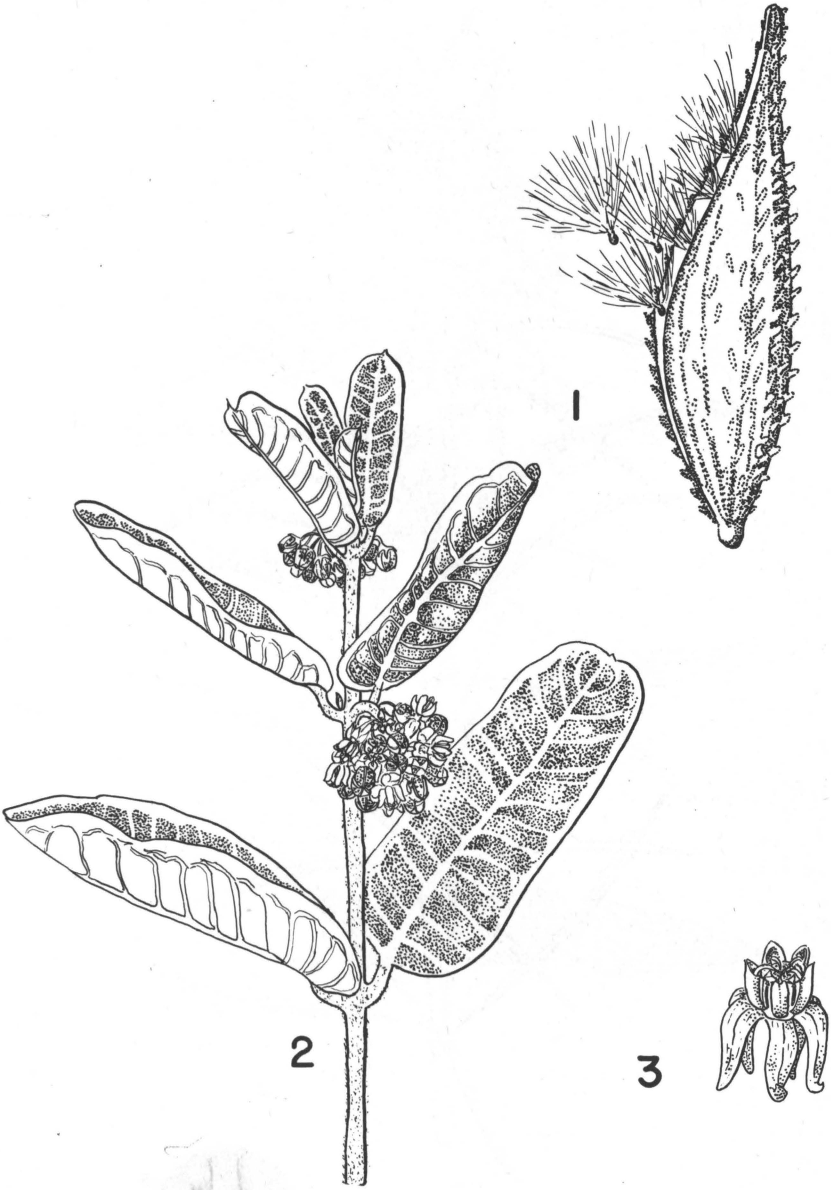


PLATE 73

Asclepias syriaca 1. Fruit x2/3. 2. Apex of plant x1/3. 3. Flower x2 1/2.

PLATE 74

Asclepias verticillata Habit x2/3.

PLATE 75

Asclepias tuberosa Habit x2/3.

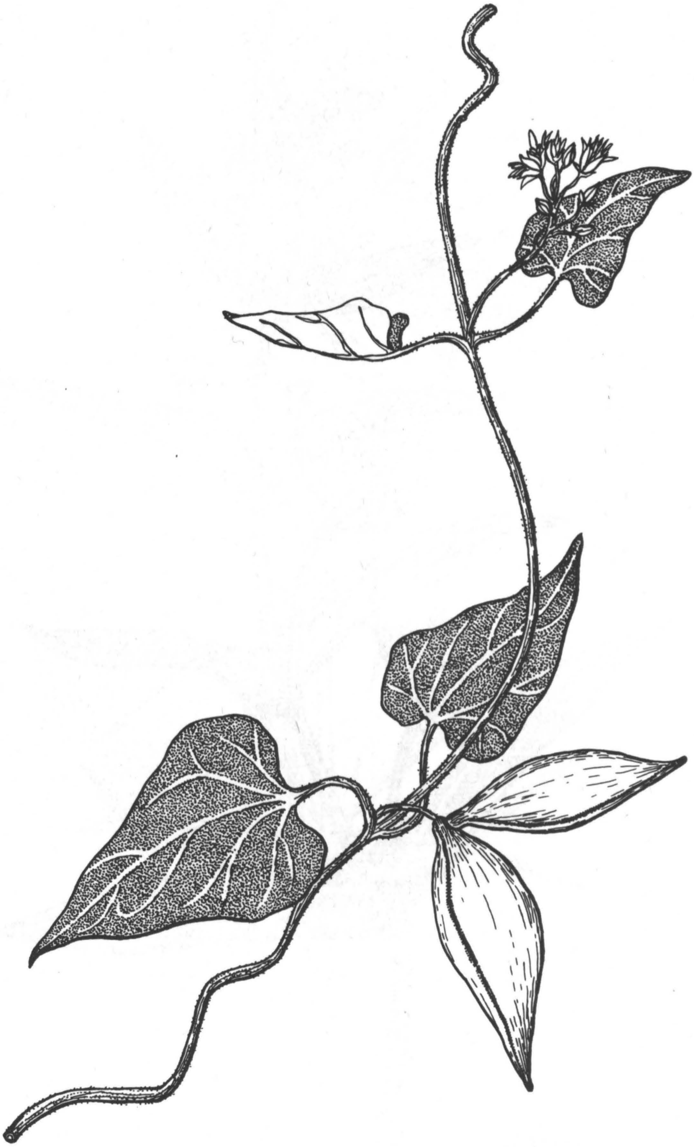


PLATE 76

Ampelamus albidus Habit x2/3.

PLATE 77

Apocynum sibericum 1. Flowering branch x1/2. 2. Pods x2/3.

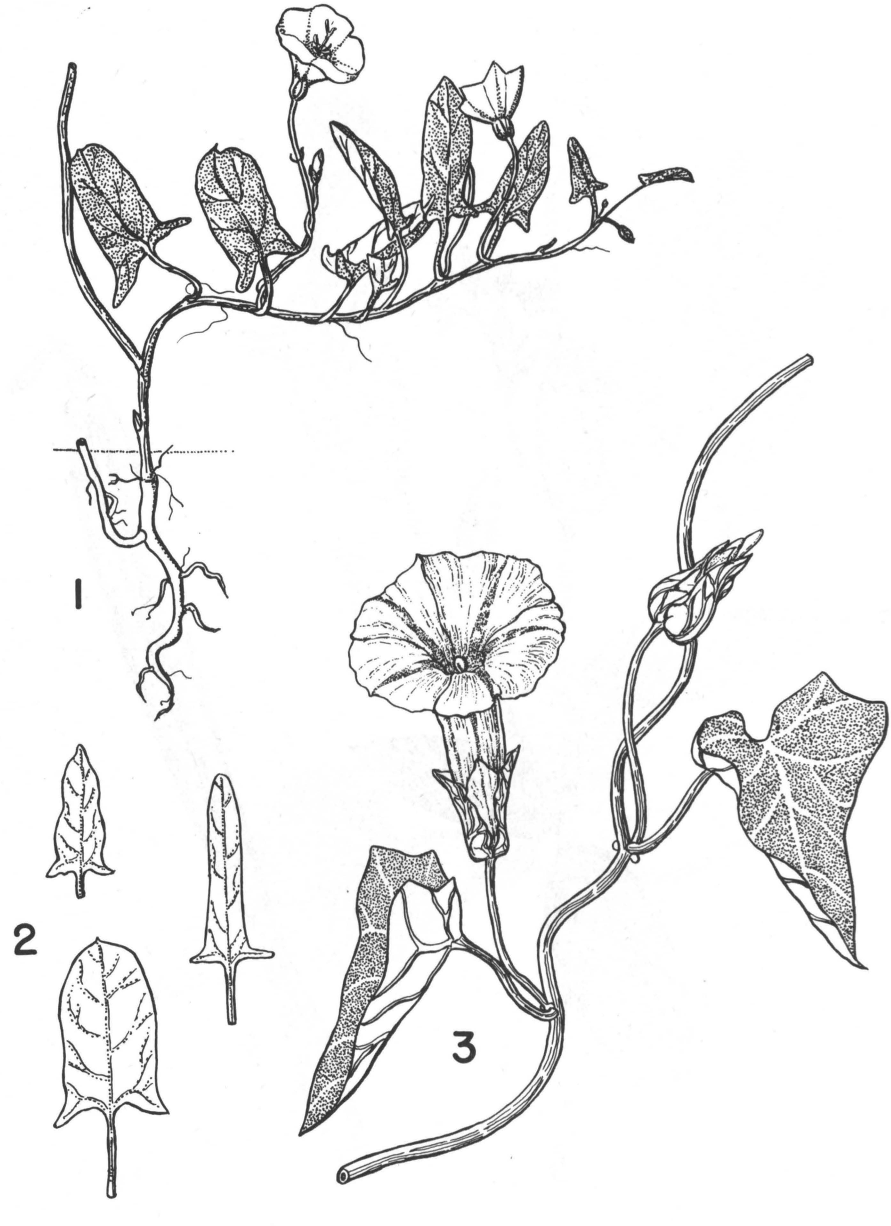


PLATE 78

Convolvulus arvensis 1. Habit x2/3. 2. Variation in leaf form x2/3.
Convolvulus sepium 3. Flowering branch x2/3.

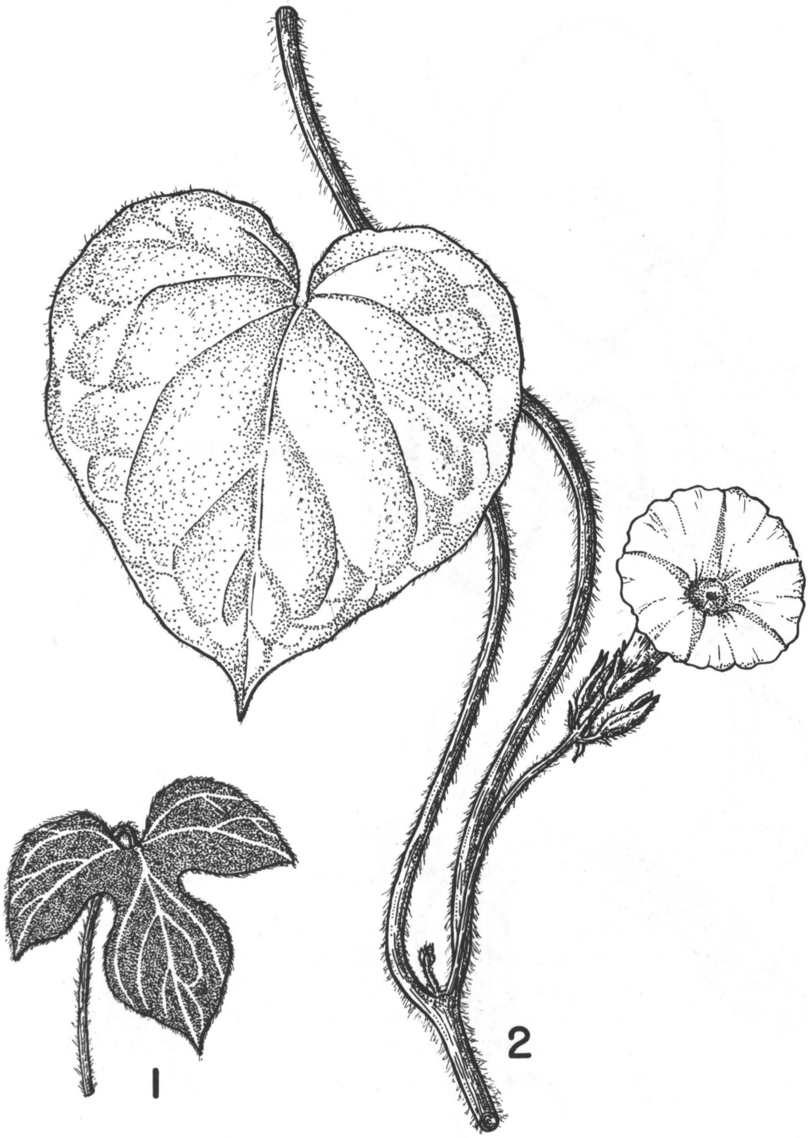


PLATE 79

Ipomoea hederacea 1. Leaf x2/3.
Ipomoea purpurea 2. Flowering branch x2/3.

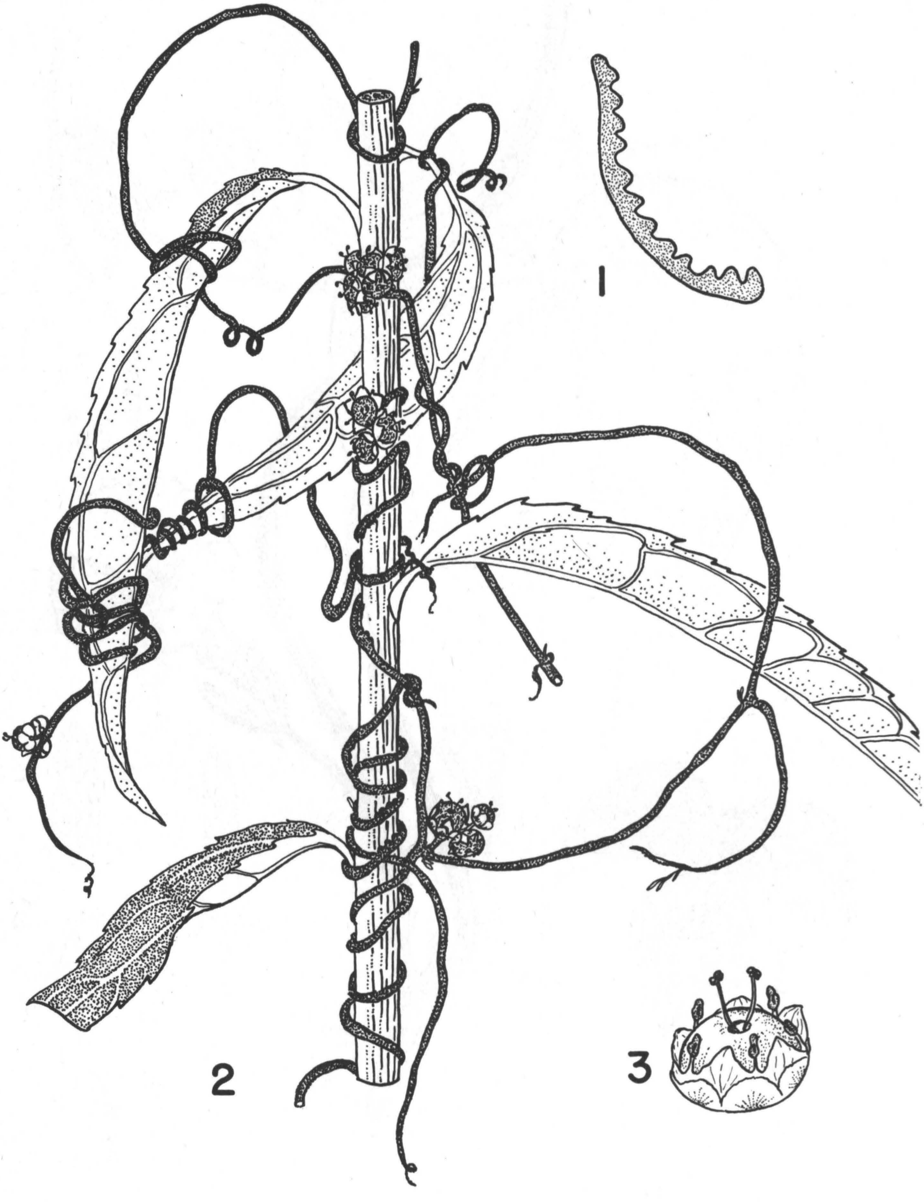


PLATE 80

Cuscuta sp. 1. Enlarged sucker x3. 2. Plant entwined on host x2/3. 3. Flower x5.

15. The Mint, Vervain, and Borage Families

THESE THREE FAMILIES have a common type of a fruit. Typically it is dry, at maturity splitting longitudinally into 4 1-seeded segments termed nutlets. These, the "seeds" of common parlance, are then shaped somewhat like a quarter section of an orange with two flat sides coming together at right angles and a curving back.

There are some exceptions to this "typical" fruit type, owing primarily to nondevelopment of some of the seeds. The number of ultimate segments, in such cases, is then less than 4, and their shape is not as above described.

LABIATAE, MINT FAMILY

Plants usually with square stems and a strong aromatic odor. Leaves simple, opposite, toothed or lobed. Flowers gamopetalous, irregular, 2-lipped.

The Labiatae contain numerous weedy species, most of them minor pests. It also includes a number of well-known garden herbs and sources of aromatic oils, e.g. peppermint, sage, thyme.

Nepeta. *Nepeta cataria*, Catnip, Catmint. Plants perennial, erect, pubescent. p144 Leaves cordate-lanceolate, dentate. Flowers in dense, interrupted, terminal spikes and axillary clusters, dirty-white in appearance. Seeds dark brown, smooth, with a pair of conspicuous white spots at the base. Roadsides, fence rows, barnyards. Summer.

Prunella. *Prunella vulgaris*, Selfheal, Heal-all. Plants erect or prostrate. p144 Leaves lanceolate. Flowers in short spikes, lavender, partially concealed by broad bracts. Seeds smooth and glossy, light brown with darker, longitudinal lines. Pastures, lawns, uncultivated areas, more common eastern portion of range. Summer.

Teucrium. *Teucrium canadense*, Germander. Perennial from creeping rootstocks. Stem erect, finely hairy. Leaves petioled, cordate-lanceolate, serrate. Flowers reddish-lavender, in loose terminal and p145 axillary racemes. Nutlets 2.5 mm. in diameter, ovoid or subspheroid, covered with a network of ridges, brownish, with a very large attachment scar. Cultivated soil, especially bottoms, roadsides. Summer. Seeds often encountered in seed oats.

Leonurus. *Leonurus cardiaca*, Motherwort. Plants perennial from rhi-
p146 zomes. Leaves palmately lobed; uppermost only toothed. Flowers in axillary clusters, the persistent, pointed calyx lobes becoming spiny after flowering. Central and eastern. Waste areas and around buildings. Summer.

p145 *Lamium*. *Lamium amplexicaule*, Henbit, Dead-nettle. Annual. Lower leaves petioled; upper blades sessile and clasping. Flowers reddish-purple, clustered in upper leaf axils. Southern and eastern. Gardens, cultivated ground, waste areas, usually in moist soil.

VERBENACEAE, VERVAIN FAMILY

Verbena, Vervain. Plants not aromatic. Leaves opposite. Flowers in spikes, blue or white, gamopetalous, regular or nearly so.

Verbena stricta, Hoary vervain. Plants perennial, erect, hairy. Stems scarcely branching below inflorescence. Leaves serrate,
p147 coarsely wrinkled and veined, densely pubescent. Flowers in dense spikes, purple-blue, 8-9 mm. in diameter. Seeds 3 mm. long, dark brown in color, the back covered with a network of longitudinal ridges and cross veins. Common, pastures. Summer to fall.

Verbena hastata, Blue vervain. Perennial. A taller, less hairy, more branching plant than the hoary vervain. Flowers bluish,
p149 small, 3-4 mm. across, in slender spikes. Seeds about 2 mm. in length, the back longitudinally ridged, with weak cross nerves. Central and eastern. Pastures, waste land, open woodland. Summer to fall.

Verbena urticaefolia, White vervain. Essentially similar to blue
p148 vervain except flowers white, in loose spikes. Pastures, open woodlands. Late summer.

Verbena bracteata, Bracted vervain, Prostrate vervain. Plants
p147 annual, prostrate. Leaves irregularly lobed or toothed. Flowers blue in dense, conspicuously bracted spikes. Nutlets reticulate on back. Central and western. Lawns, around buildings, trampled areas, often succeeding in dry sterile soil. Summer and fall.

BORAGINACEAE, BORAGE FAMILY

Leaves alternate. Flowers regular. Nutlets often with tubercles or hooked bristles.

The family contains a number of species of somewhat weedy nature, several of which may be found in the North Central States. Only the following seems common enough to deserve specific description.

Lappula. Lappula echinata, Stickseed. Plant annual, pubescent. Leaves sessile, narrowly oblong, entire. Flowers blue, small. Fruit splitting into 4 bristly one-seeded nutlets. Common, pastures and hay p150 fields, roadsides. Summer. The seeds are occasional in legume and grass seeds, usually with the barbs broken off so that the surface appears only knobby. In the field the fruits will readily adhere to clothing or to animals.

PLATE 81

Prunella vulgaris 1. Habit x2/3.
Nepeta cataria 2. Habit x2/3. 3. Flower x4.

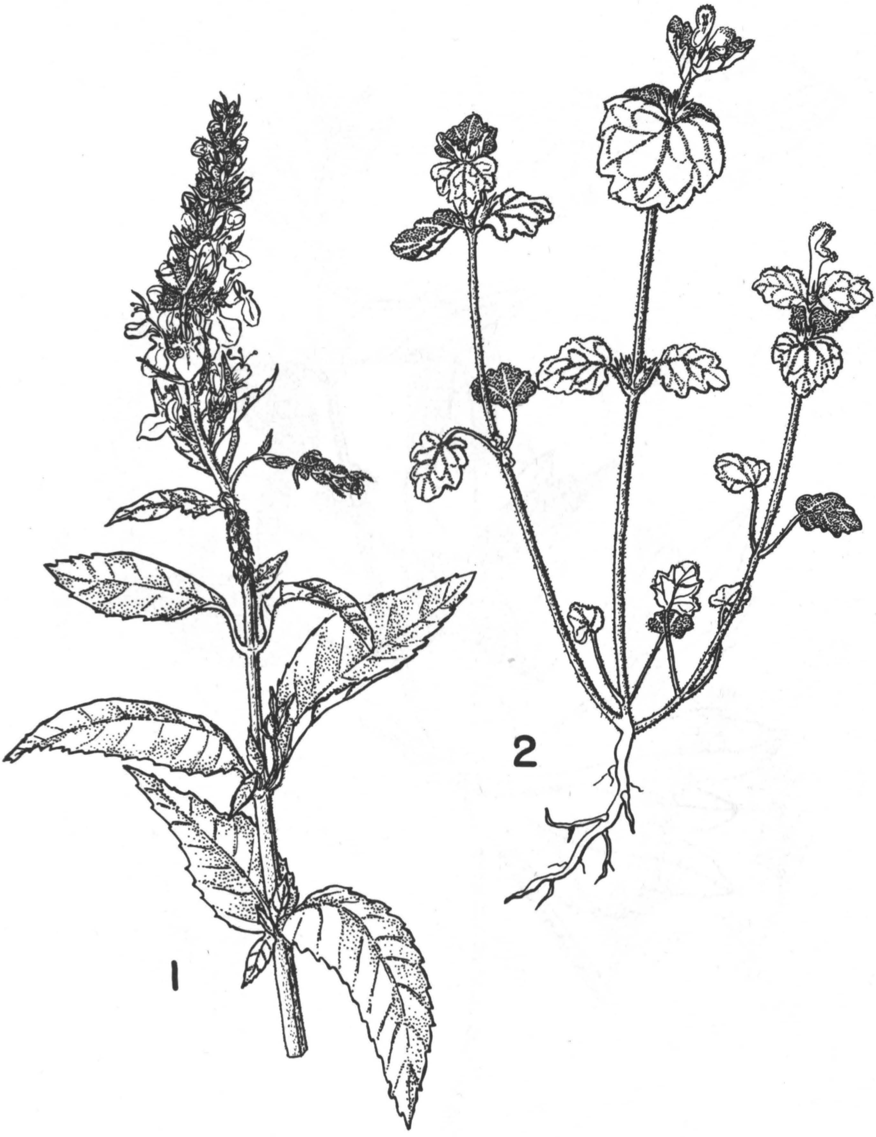


PLATE 82

Teucrium canadense 1. Inflorescence and upper leaves x2/3.
Lamium amplexicaule 2. Habit x2/3.

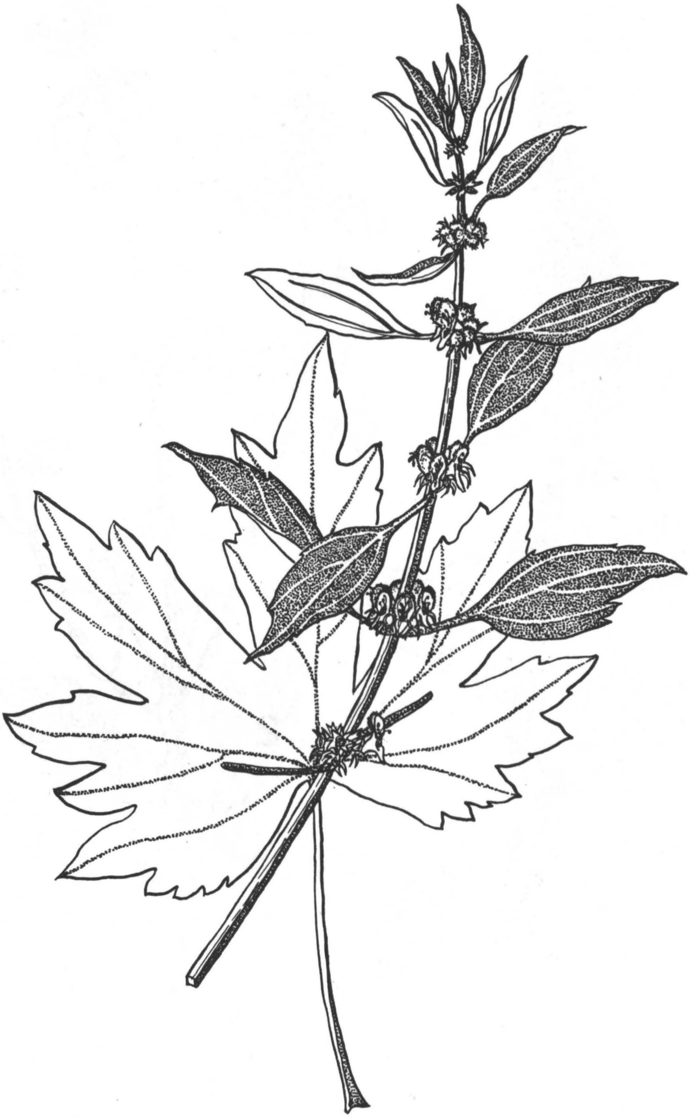


PLATE 83

Leonurus cardiaca Habit and basal leaf x2/3.

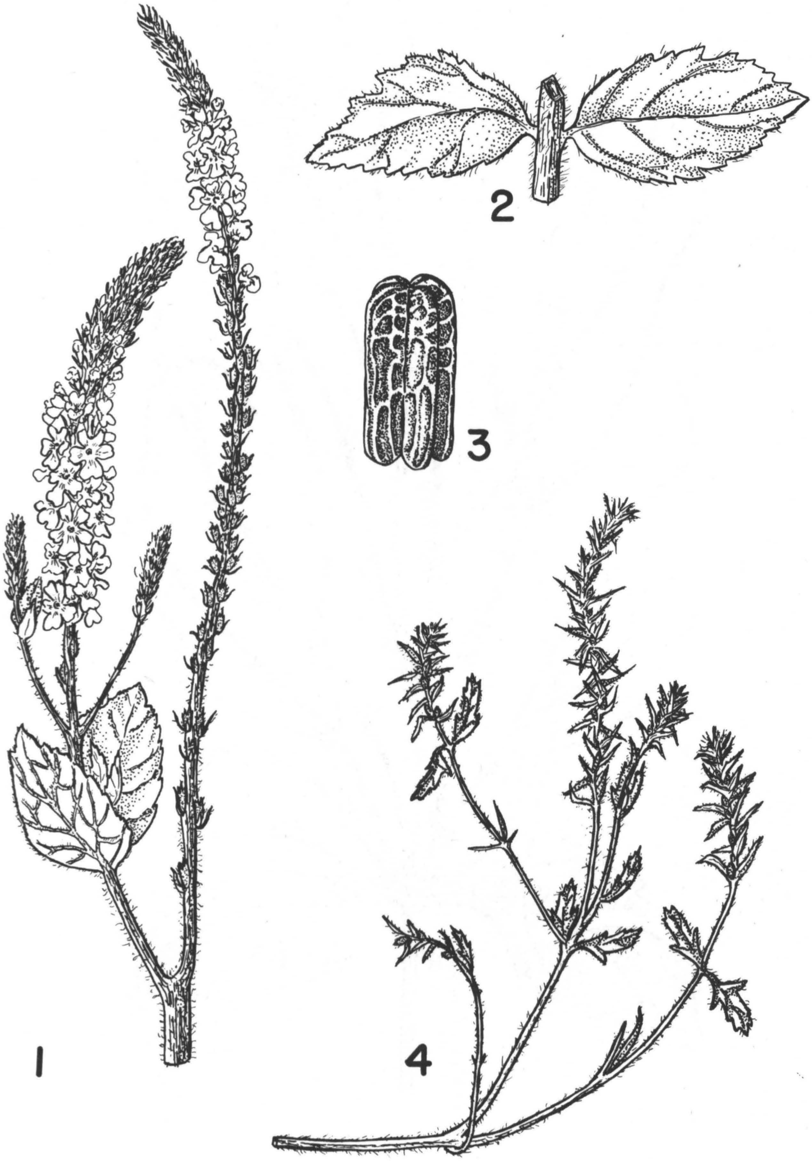


PLATE 84

Verbena stricta 1. Inflorescence x2/3. 2. Opposite leaves x2/3. 3. Nutlet cluster x7.

Verbena bracteata 4. Habit x2/3.

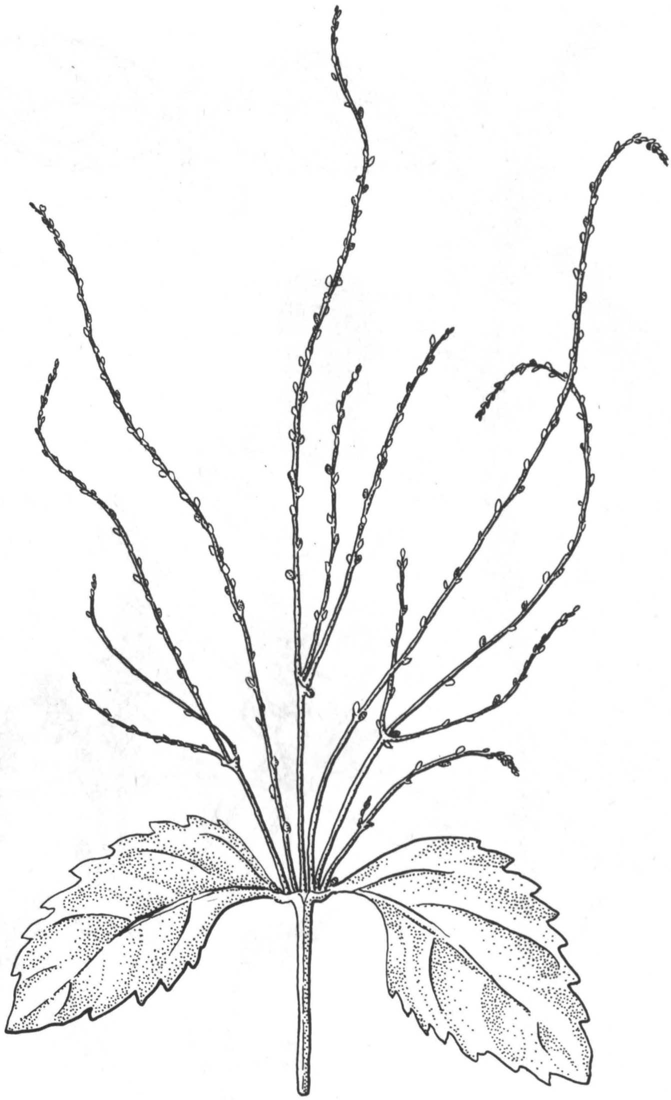


PLATE 85

Verbena urticaefolia Apex of plant x2/3.

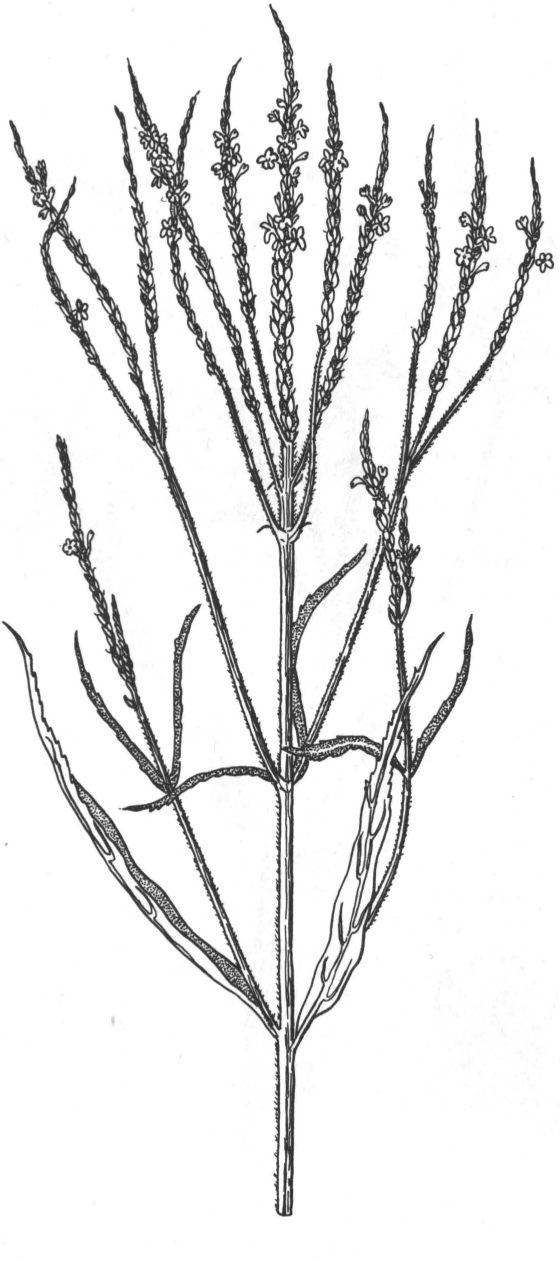


PLATE 86

Verbena hastata Flowering branch x2/3.

PLATE 87

Lappula echinata 1. Fruit x7. 2. Apex of plant x2/3.

16. The Potato, Plantain, and Miscellaneous Families

SOLANACEAE, POTATO FAMILY

LEAVES ALTERNATE. Flowers gamopetalous, regular, tubular, or with a tube and expanded limb. Fruit a berry or capsule. Seeds often flattened, irregularly circular with the hilum marginal, in some kinds thicker with a mesh-like seed coat.

This large and diverse plant family not only contains many weeds but numerous well-known cultivated plants, e.g. tobacco, Irish potato, eggplant, tomato, peppers, petunia.

Physalis, Groundcherry. Stems ascending, much branching. Leaves petioled, ovate to ovate-lanceolate. Flowers pale yellow with a purplish p155
center. Fruit a berry enclosed by the bladdery-inflated calyx. Seeds golden-yellow, usually nearly symmetrical in outline, the hilum located in a small notch in the middle of one of the edges. The seed coat is typically finely bumpy, appearing somewhat as if sugar-coated. Some kinds, however, have less distinctly roughened coats and are easily confused with those of horsenettle (see below). The seeds are not infrequently found in those of small-seeded legumes and forage grasses.

The ground cherries are rarely encountered in cultivated soil but are usually seen in grassland, along roadsides, etc. Several kinds occur in the North Central States. These include both annual and perennial species. Some kinds are densely sticky hairy and are called "clammy ground cherries." Others, usually with longer, narrower leaves, are less pubescent and may be termed "smooth ground cherry."

Solanum. Plants diverse in appearance. Fruit a berry, not enclosed in a husk as above, in one species spiny.

Solanum carolinense, Horsenettle. Plants perennial from p157
creeping roots, spiny. Leaves shallowly lobed, often oak-like in appearance. Flowers white or lavender with a yellow center. Fruit a yellow berry. Seeds irregular in outline, the margin frequently angled, faintly roughened by low curving ridges. Primary noxious or prohibited in most states. Widely distributed but major importance primarily in eastern and southern portion of range. Nearly all habitats, spreading aggressively from roots.

Solanum elaeagnifolium, White horsenettle. Similar to horsenettle; leaves narrower, sinuate-margined, white-hairy. Noxious in several southern and western states, entering the North Central States only in the extreme southwest.

p156

Solanum rostratum, Buffalo bur. Plants annual, very spiny. Fruit a dry berry enclosed by a spiny covering (the calyx). Seeds blackish, the surface honeycomb-like in appearance. Principally uncultivated soil, about buildings, feed lots, overgrazed pastures, roadsides, etc. More common southwest. Summer.

p157

Solanum nigrum, Black nightshade. Plants annual, not spiny. Leaves ovate, wavy-margined. Flowers white, small. Fruits small berries, purple-black when mature. Cultivated soil and waste areas. Summer and fall. The unripe (green) berries and foliage may be poisonous.

p158

p159 *Datura. Datura stramonium*, Jimson weed. A rank, often tall annual. Leaves shallowly lobed. Flowers trumpet-shaped, large, 1-2 d.m. long. Fruit a large, spiny capsule. Fertile soil, around buildings, feed lots and waste areas. Primarily southern. Summer.

SCROPHULARIACEAE, FIGWORT FAMILY

Leaves alternate or opposite. Flowers gamopetalous, irregular in most genera (but not in *Verbascum*). Fruit a capsule.

Verbascum, Mullein. As described below.

p160 *Verbascum thapsus*, Mullein, Torch plant. Plants biennial, tall (1-2 m. if well developed), densely woolly. Flowers in a terminal spike, regular, yellow. Fruit a capsule. Seeds very small, less than 1 mm. in length. Dry sandy soil, pastures and waste ground. Summer.

p160 *Verbascum blattaria*, Moth mullein. Biennial, but smaller than above and not woolly. Flowers in a loose raceme. Mostly eastern.

Linaria. Linaria vulgaris, Yellow toadflax, Butter-and-eggs. Perennial

p161 from creeping rootstocks. Stems closely leafy with sessile, strap-shaped blades. Flowers yellow and orange in terminal racemes; corolla with a conspicuous backwards-pointing spur. Seeds circular, "scale-like," black. Usually in uncultivated areas. Northeast.

Veronica, Speedwell. Several small, low or creeping, annual or winter

p161 annual species. Lower leaves opposite; upper often alternate. Flowers (in our species) very inconspicuous in leaf axils, blue or white. Fruits heart-shaped with notch at top. Gardens, lawns, waste areas. Eastern. Usually most conspicuous in the spring.

PLANTAGINACEAE, PLANTAIN FAMILY

Leaves all in a basal cluster (in common weedy species). Flowers greenish, borne in a slender, leafless spike. Fruit a 2-chambered capsule bearing 2 to many seeds. The capsule is dehiscent by an apical lid.

Plantago, Plantains. Characters of the family.

Plantago aristata, Bracted plantain. Plants annual. Leaves linear. Spikes conspicuously bracted. Seeds two, boat-shaped, brownish on the back, white-rimmed on the inside, with a laterally directed medial groove on the back. Southern only. Pastures, grassland, legumes, usually in poor soil. Seed common in those of small-seeded legumes and grasses, and often considered secondary noxious or restricted. p162

Plantago lanceolata, Buckhorn, Narrow-leaf plantain, Ribgrass. Plants perennial. Leaves lanceolate. Spike stalk much longer than the spike itself. Seeds two, boat-shaped but thicker than those of bracted plantain, shiny brown in color. More common eastward. Legumes, lawns, roadsides. The seeds are common in those of forage legumes. p163

Plantago major, Common plantain, Ripple-seed plantain, Broad-leaved plantain. Plants perennial. Leaf petioles usually greenish at base; blades ovate, finely hairy, dull green in color. Flower spikes longer than the supporting stalk. Lid of capsule separating about the middle. Seeds numerous, irregularly polyhedral in shape, brownish, covered with fine ridges and lines. Central and eastern, lawns, waste areas, pastures, legumes. Summer and fall. p164

Plantago rugelii, Rugels plantain, Black-seeded plantain, Broad-leaved plantain. Similar to common plantain, differing only as follows: leaf petioles usually reddish at base; blades shiny green. Lid of capsule separating below the middle. Seeds black in color, appearing like tiny lumps of coal. Occurring in the same situations as common plantain, but more frequent. Seeds in those of legumes, forage grasses, and lawn seed mixtures. p165

Plantago purshii, Woolly plantain. Annual with woolly, linear leaves. Spike elongate. Seeds boat-shaped, thin, reddish-brown. Western plains. Ranges and waste areas. Summer. p164

RUBIACEAE, MADDER FAMILY

Diodia. *Diodia teres*, Buttonweed. Plants annual, low. Leaves opposite, sessile, small, oblong-lanceolate. Flowers sessile in leaf axils, pinkish. Fruits topped by four persistent calyx lobes, splitting longitudinally at maturity into 2 1-seeded segments. Extreme South. Sterile soil. Summer. p166

Galium, Bedstraw, Cleavers. Plants "sticky," readily adhering to clothing from fine, hooked hairs which cover stems and leaves. p166 Leaves sessile, whorled, 6 to 8 at each node. Flowers small, whitish. Fruits of two attached, somewhat ball-shaped segments, covered with bristles, these each containing a single seed and separating at maturity. Roadsides, pastures, openings under trees, usually in moist soil. "Seeds" (fruit segments) occasional in crop seeds, bristles mostly broken off, with a conspicuous concavity in one side.

CAPRIFOLIACEAE, HONEYSUCKLE FAMILY

Symphoricarpos, Buckbrush. Shrubs with opposite, oval, usually entire leaves. Flowers white or greenish, clustered towards branch tips or in leaf axils. Fruit berry-like, with two seeds. Pastures and ranges, widely distributed, perhaps most common in south central portion.

p167 *Symphoricarpos albus*, Buckbrush, Snowberry. Flowers white. Fruits white, about 10 mm. in diameter.

p167 *Symphoricarpos orbiculatus*, Buckbrush, Coralberry. Flowers greenish-purple. Fruits reddish, about 5 mm. in diameter.

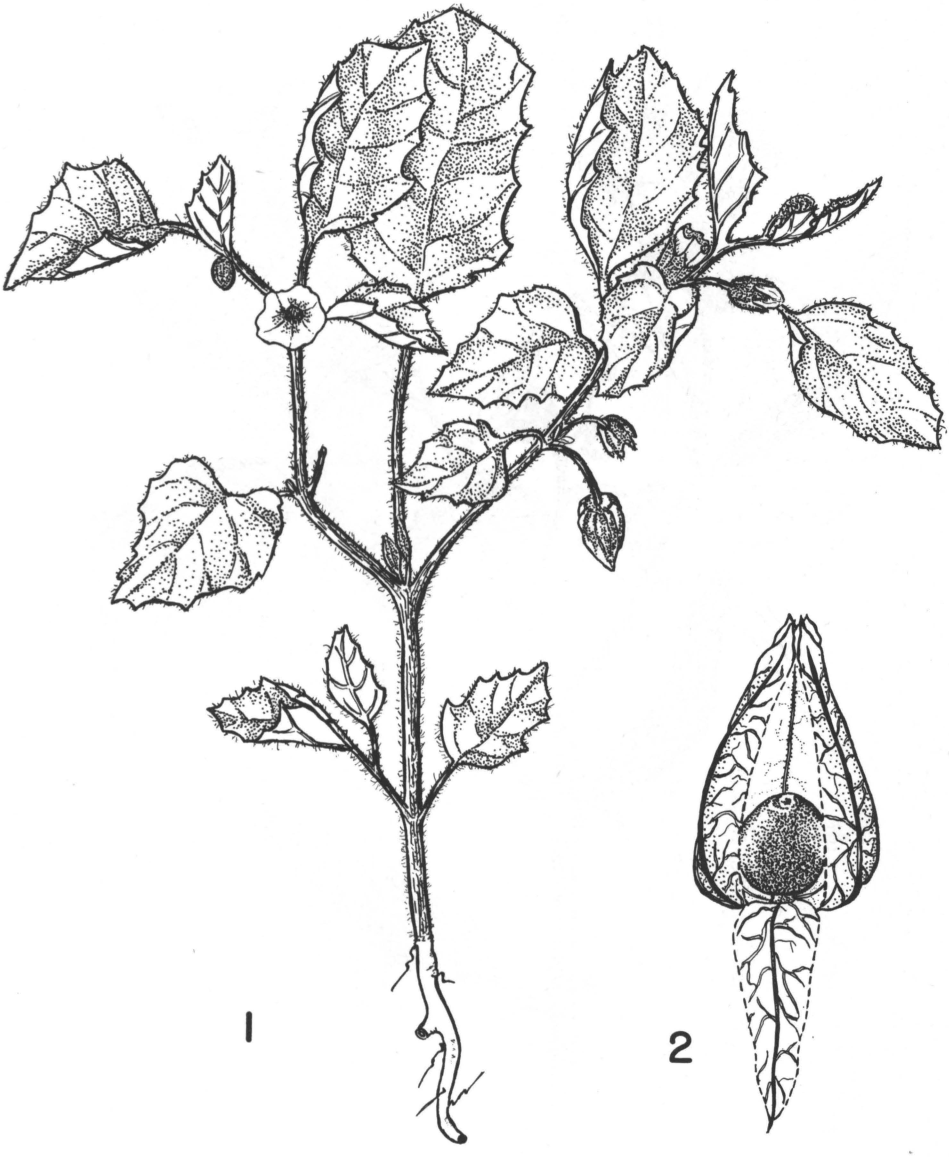


PLATE 88

Physalis heterophylla 1. Habit x2/3. 2. Fruiting calyx with enclosed berry x1 1/3.

PLATE 89

Solanum elaeagnifolium Habit x2/3.

PLATE 90

Solanum rostratum 1. Flowering branch x1/2.
Solanum carolinense 2. Apex of plant x2/3. 3. Perennial root x2/3.

PLATE 91

Solanum nigrum Flowering branch x2/3.

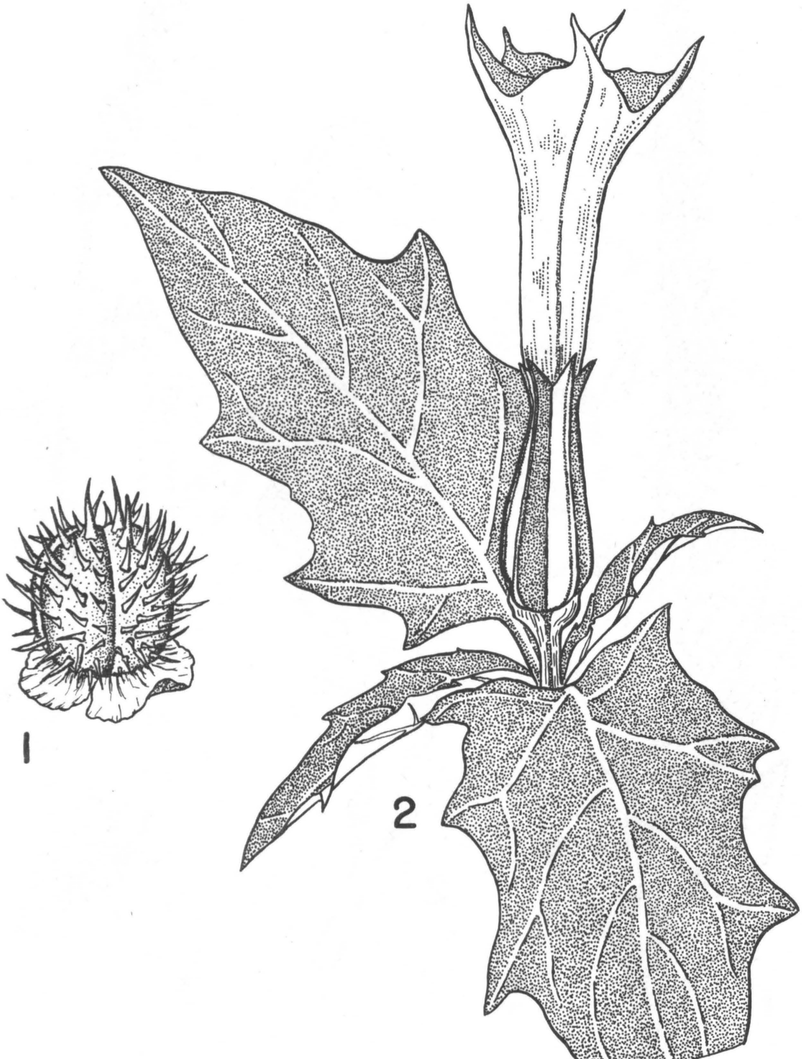


PLATE 92

Datura stramonium 1. Fruit x2/3. 2. Leaves and flower x2/3.

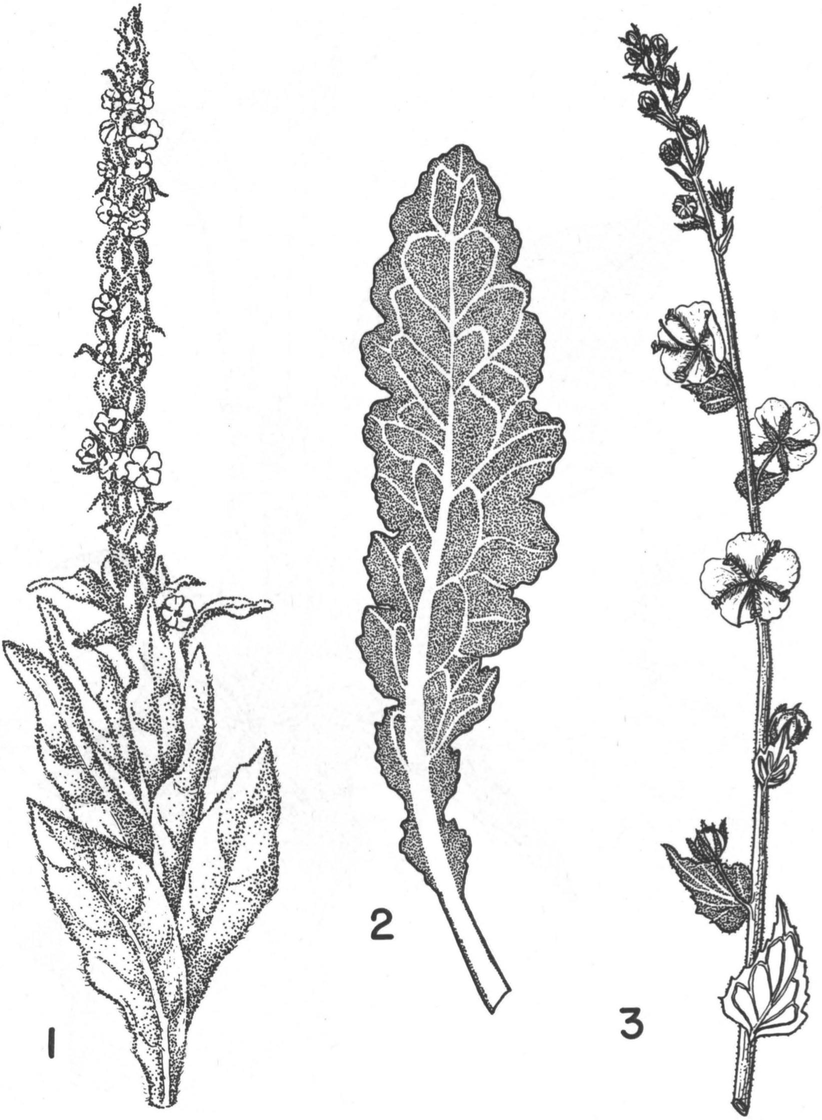


PLATE 93

Verbascum thapsus 1. Stem apex x1/3.
Verbascum blattaria 2. Basal leaf x2/3. 3. Inflorescence x2/3.

PLATE 94

Linaria vulgaris 1. Stem apex x1/3.
Veronica peregrina 2. Habit x2/3.

PLATE 95
Plantago aristata Habit x2/3.

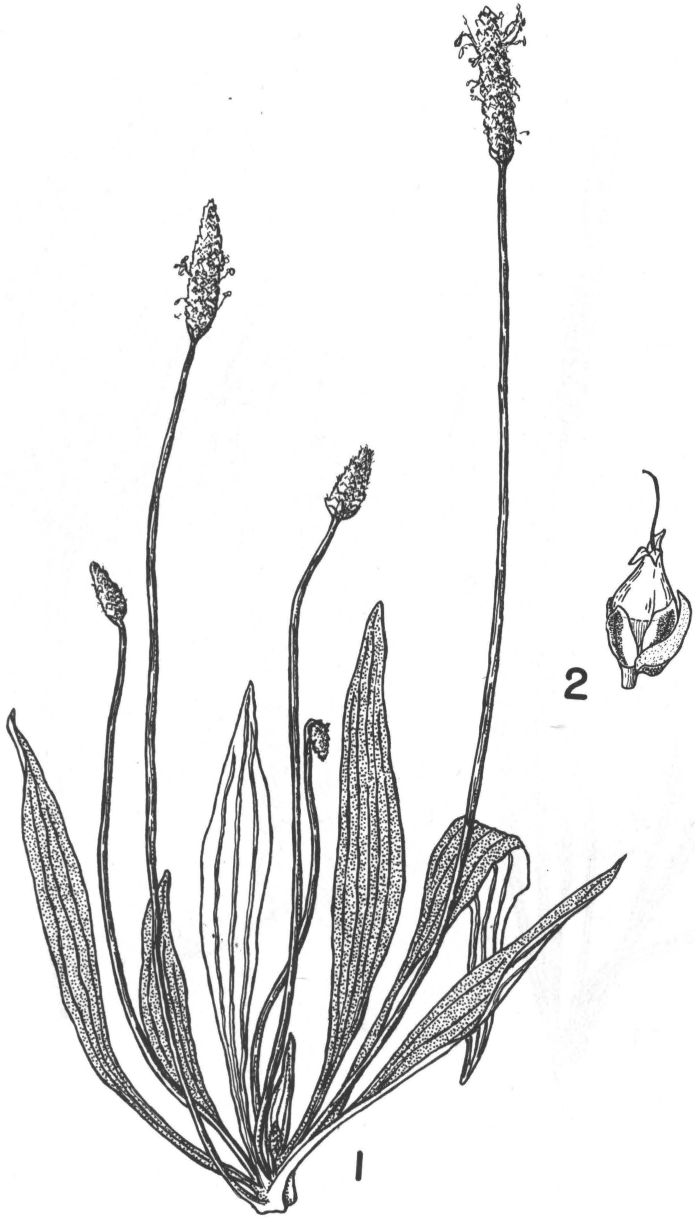


PLATE 96

Plantago lanceolata 1. Habit x2/3. 2. Fruit x5.

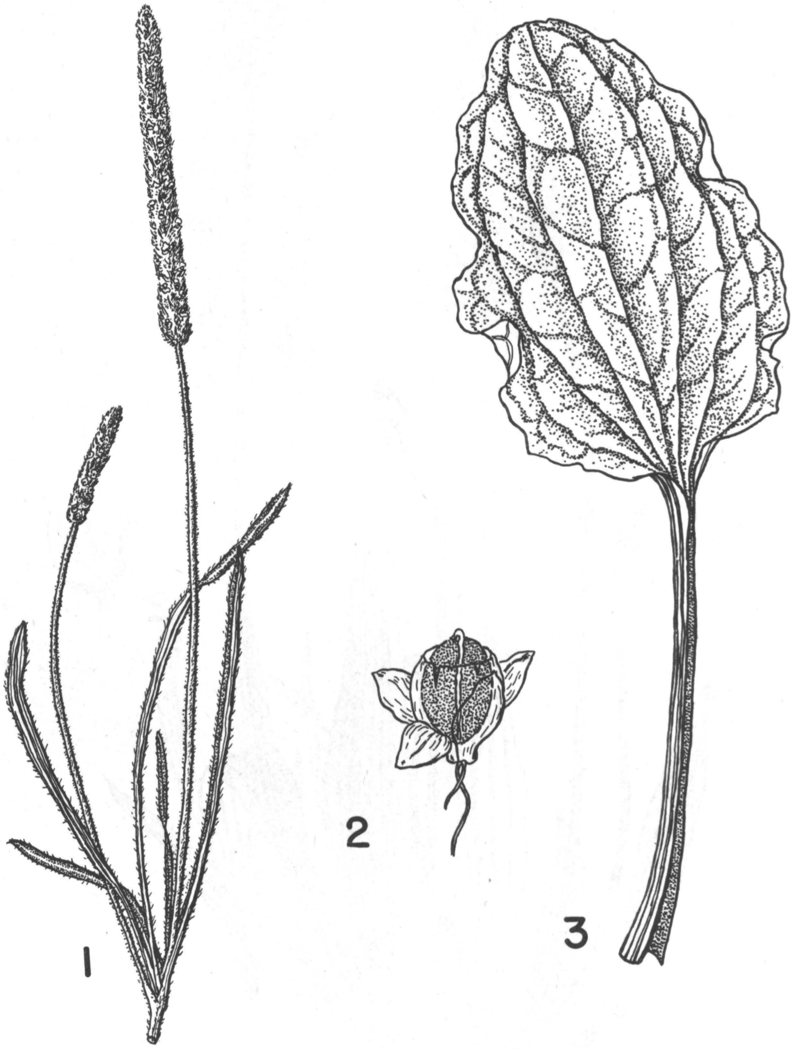


PLATE 97

Plantago purshii 1. Habit x2/3.
Plantago major 2. Capsule semi-diagrammatic x5. 3. Leaf x2/3.

PLATE 98

Plantago rugellii 1. Capsule, semi-diagrammatic showing separation of lid x5. 2. Habit x1/2.

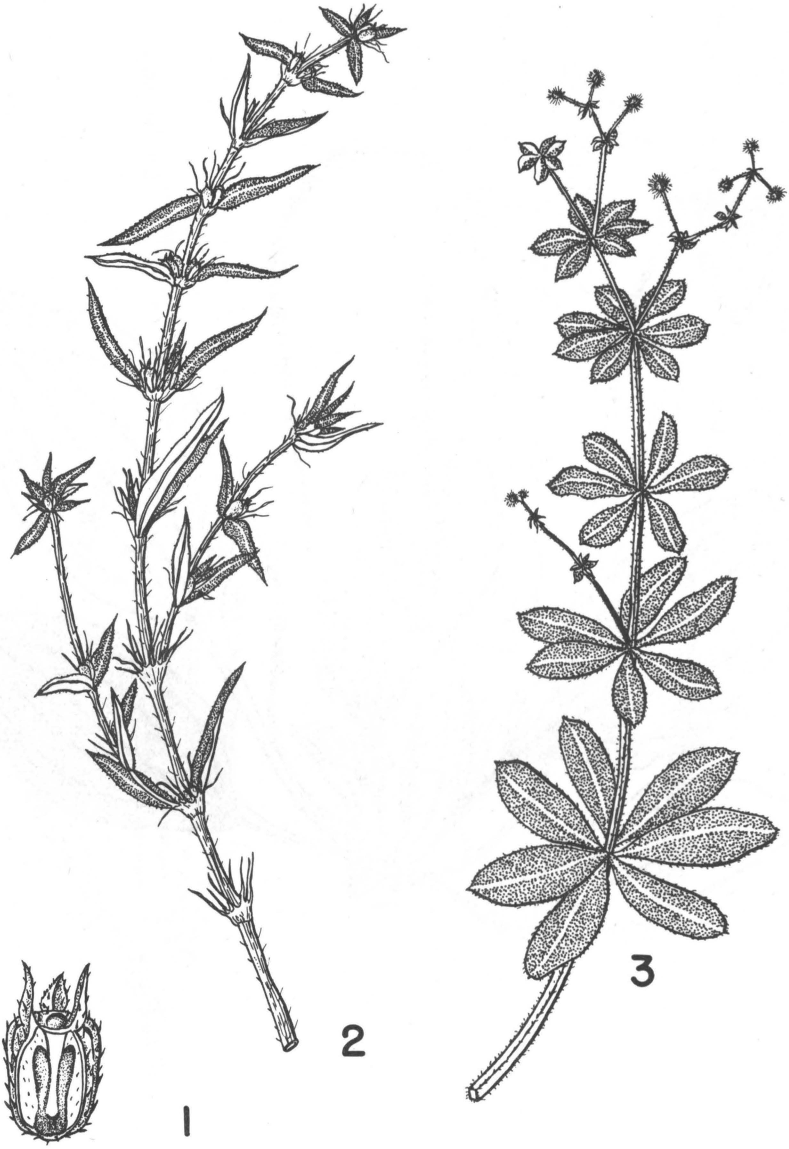


PLATE 99

Diodia teres 1. Fruit x4. 2. Fruiting branch x2/3.
Galium triflorum 3. Flowering branch x2/3.

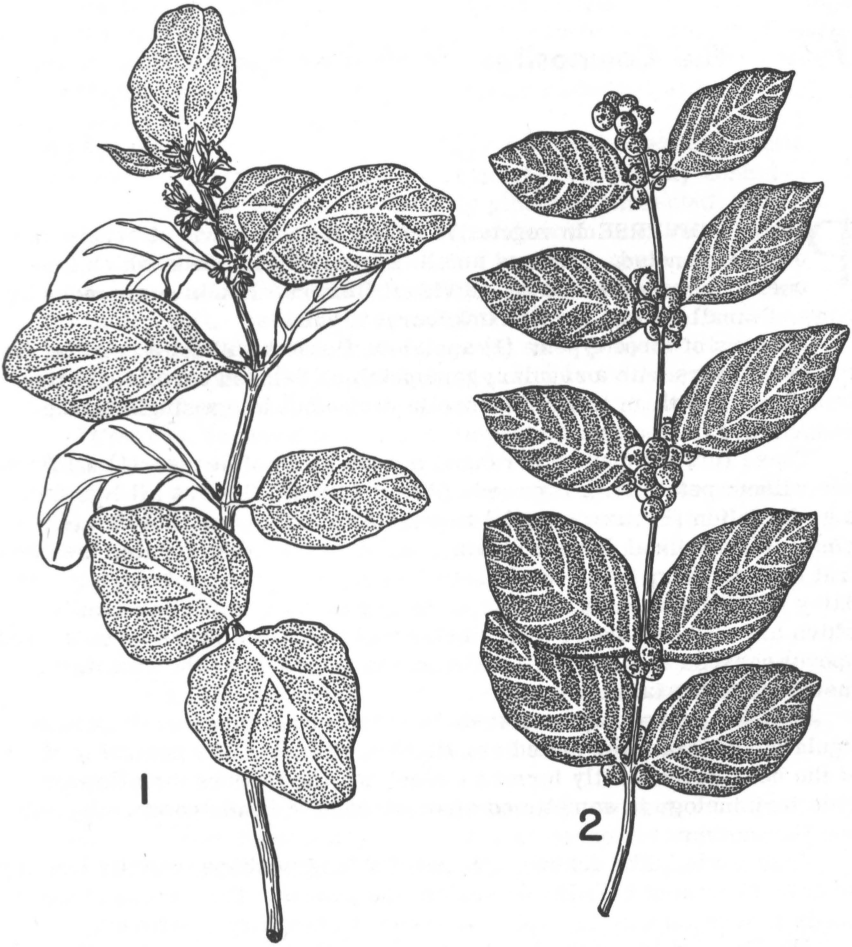


PLATE 100

Symphoricarpos albus 1. Flowering branch x2/3.
Symphoricarpos orbiculatus 2. Fruiting branch x2/3.

17. The Compositae, Sunflower Family

PLANTS DIVERSE in vegetative characters. Leaves alternate unless otherwise noted. Flowers small, aggregated in heads which frequently appear like large individual flowers. Heads surrounded by rows of small bracts, termed involucral bracts.

Flowers of three types: (1) apetalous flowers without a corolla, (2) tubular flowers with a regular, gamopetalous 5-lobed corolla, (3) ligulate flowers with an irregular corolla drawn out into a single, strap-shaped lobe.

These flowers may be arranged in four kinds of heads: (1) all flowers without petals, e.g. ragweeds *(Ambrosia)*, (2) flowers all ligulate, e.g. dandelion *(Taraxacum)*, (3) flowers all tubular, e.g. thistles *(Cirsium)*, (4) marginal flowers ligulate and appearing like petals; the central ones tubular; these two kinds often of contrasting colors, e.g. oxeye daisy *(Chrysanthemum)*. Those members of the Compositae family which have heads composed exclusively of ligulate flowers (second group above) possess a milky juice. The sap is not milky in the remaining members of the family.

In heads possessing both kinds of petaliferous flowers, the marginal ligulate ones are often called ray flowers or rays. The central portion of the head is frequently termed a disk, and the flowers disk flowers. This terminology is sometimes also extended to heads possessing only one flower type.

Fruit a seed-like achene, generally oblong in shape, usually bearing an apical crown of bristles or scales, the pappus. The pappus of weed seeds processed with agricultural seeds is generally destroyed.

The Compositae is the largest family of flowering plants on the basis of number of species. It possibly contains more weedy kinds than any other family group. On the other hand, it possesses few plants of real economic value other than ornamentals. Garden lettuce and endive are members of this family. Ornamentals belonging to the Compositae include chrysanthemums, cosmos, coreopsis, daisy, calendula, marigolds and zinnias.

The genera following are grouped according to type of flower head as categorized above.

FLOWER HEADS GREENISH WITHOUT PETALS

Ambrosia, Ragweed. Plants annual, erect, branched. Flowers much reduced, unisexual, the pistillate and staminate in separate heads. Pistillate heads in small clusters in axils of upper leaves, reduced to a single flower surrounded by involucral bracts. Staminate heads many-flowered, in long terminal spikes. "Seed" consisting of the achene surrounded by the hardened, persistent involucre, irregularly obovoid with three or four points at the apex. Pappus absent.

Ambrosia elatior (A. artemisiifolia), Common ragweed, Small ragweed. Plants annual, to 1 m. in height, but usually considerably smaller. Leaves irregularly pinnately dissected, the lower opposite, upper alternate. Seeds brown in color, 3-4 mm. long. Abundant, usually grasses and legumes, grain stubble, pastures, waste ground in both rural and urban areas, successful in dry soil. Late summer and fall. Seeds common in legume seed, occasional in oats and soybeans; when subjected to the action of cleaning machinery the outer involucre is sometimes stripped off exposing the brown, somewhat shiny, obovoid achene. p176

Common ragweed is the most important late summer hay fever plant.

Ambrosia trifida, Giant ragweed, Horseweed. Plants annual, often 2-3 m. in height. Leaves opposite, 3-lobed. Seed brown in color, 6-9 mm. in length. Abundant in rich, usually moist soil; gardens, roadsides, waste ground, river bottoms. Late summer. Also a source of hay fever but less important than above. p177

Ambrosia psilostachya, Perennial ragweed. Plants perennial from creeping roots, usually not more than 5 dm. tall and occurring in clusters or patches. Leaves similar to those of common ragweed but less finely divided. Western. A variety of habitats. p177

Ambrosia bidentata, Lance-leaved ragweed. Annual, usually small. Leaves lanceolate, with a pair of conspicuous lobes or teeth at base. Extreme southern. Pastures and uncultivated soil. p177

Franseria. Franseria discolor, Bur ragweed. Plants perennial from creeping roots. Leaves pinnately dissected. Flower heads similar to those of ragweeds, without petals; staminate and pistillate flowers in separate heads. Pistillate heads in axils of upper leaves, enclosing 2 to 3 seeds, the entire structure becoming a spiny bur at maturity. Western in diverse habitats. p178

Iva. Lower leaves opposite. Flower heads small, greenish, somewhat similar in appearance to those of ragweeds, but pistillate and staminate flowers in some heads. Petals not present. Achenes obovoid, without a pappus.

Iva axillaris, Poverty-weed. Low perennial from creeping p179

roots. Leaves sessile, oblong, entire. Heads hanging from upper leaf axils. Western. Cultivated and untilled soils.

p179 *Iva xanthifolia*, Marsh-elder. A tall annual with long petioled, broad, irregularly toothed leaves. Heads in terminal panicles. Central and western; usually moist, bottom soil, roadsides, about dwellings and feed lots, locally conspicuous.

p180 *Xanthium*, Cocklebur. Plants annual, erect or spreading. Leaves cordate, toothed or lobed, rough in texture. Flowers and heads unisexual, greenish, without petals. Pistillate head 2-flowered; involucral bracts fused and forming the well-known 2-seeded bur. Seeds (rarely seen separate from bur) flattened, fragile, brownish in color. Common, cultivated fields, oat stubble, around feed lots and buildings, waste areas, river bottoms. Late summer and fall. The seedlings are poisonous to hogs.

FLOWER HEADS ENTIRELY OF LIGULATE FLOWERS; JUICE MILKY

p181 *Cichorium*. *Cichorium intybus*, Chicory. Perennial from a taproot. Juice milky. Leaves mostly basal, resembling those of dandelion. Stems nearly naked with a few reduced, often nearly entire leaves. Flower heads with blue, ligulate flowers. Achenes finely granular, somewhat brick-shaped, with a very short pappus. Roadsides (often conspicuous), pastures, grassland. Central and eastern.

p182 *Hieracium*. *Hieracium aurantiacum*. Orange hawkweed. Plants perennial with basal rosettes and stolons and with a milky juice. Erect stem scapose, bearing only a cluster of orange flower heads at apex. Flowers all ligulate; corolla toothed at apex. Achenes cylindrical, black, longitudinally ribbed, with a pappus of stiff bristles. Northeastern. Noncultivated areas. A yellow-flowered hawkweed *(H. pratense)* is sometimes found in similar areas.

Lactuca, Lettuce. Plants with milky juice. Leaves entire to irregularly pinnatifid, frequently prickly-toothed along margins. Heads entirely of ligulate flowers, yellow or blue. Pappus of fine bristles, often borne above achene on a beak or stalk.

p183 *Lactuca scariola*, Prickly lettuce. Plants annual or winter annual. Leaves alternate, usually pinnatifid, prickly along the margins and the back of the midrib, those on the stem twisted into a vertical position. Heads panicled, small. Flowers pale yellow. Seeds about 3 mm. in length, flattened, longitudinally ribbed, brown in color, tipped by a long beak which bears the pappus at apex. Common, gardens, roadsides, and fields. Summer. Seeds occasional in legume and grass seed.

Lactuca spp., Wild lettuce. Several species, perennial or annual, with blue or yellow flowers. One kind has black achenes with a sessile pappus. These species are less frequent in cultivated soil than prickly lettuce. None have the conspicuously prickly midrib of *L. scariola* or the characteristic vertical positioning of the stem leaves.

Sonchus, Sowthistles. Plants erect, mostly glabrous, with milky juice. Leaves irregularly lobed or toothed, soft-prickly. Flowers all ligulate, yellow. Seeds reddish-brown, roughened by closely crowded longitudinal ridges, and cross wrinkles; pappus of fine bristles.

Sonchus arvensis, Perennial sowthistle. Plants perennial from creeping roots. Leaves rather evenly prickly-toothed. Heads nearly the size of those of dandelions. Seeds oblong; longitudinal ribs regular, easy to count. Primary noxious or prohibited in all states except the southern; of major importance only in northern areas. Cultivated and uncultivated ground. Summer. p184

Before flowering, this plant is easily confused with prickly lettuce and annual sowthistle. Note that leaves of the lettuce are prickly on lower midrib and are held in a vertical plane. The two sowthistles can most easily be distinguished in early stages of growth by the shallow, annual taproot, and irregularly prickly leaves of the annual sowthistle.

Sonchus oleraceus, Annual sowthistle. Plant annual. Leaves irregularly pinnatifid and spinulose toothed. Flower heads much smaller than that of a dandelion. Achenes broadening to top with irregular (difficult to count) ribs. Waste areas, about buildings, usually not abundant but widely distributed. Summer and fall. p185

Taraxacum. *Taraxacum officinale*, Dandelion. Plants perennial, with a rosette of pinnatifid leaves, and hollow leafless stalks each bearing a single, large, yellow head of ligulate flowers. Seeds oblong, longitudinally ribbed, barbed near apex, brownish, apically tapering into a long beak which bears the feathery pappus. Abundant, lawns, pastures, and meadows. Spring. Seeds common in lawn grass mixtures; occasional in forage grass seed. p186

Tragopogon, Goat's-beard, Salsify. Plants biennial, erect, with milky juice. Leaves alternate, linear-lanceolate, entire, fleshy, somewhat grass-like in appearance. Heads solitary at stem tips, large, 4-5 cm. in diameter, of yellow (rarely purple) ligulate flowers. Seeds 10-13 mm. in length, narrowly oblong, beaked, bearing a bristly pappus. Common, roadsides, fence rows. Early summer. p186

FLOWER HEADS ENTIRELY OF TUBULAR FLOWERS

Antennaria, Pussy's-toes, Ladies'-tobacco. Creeping or low white-woolly plants with spatulate leaves. Flower heads in small clusters at tip of erect stems. Flowers white, all tubular. Primarily southeast. Flowering in spring but growth continues during summer. Eroded or sterile, noncultivated soil. p187 p187 *Arctium. Arctium minus*, Burdock. Plants biennial with a rosette of large, petioled, usually cordate blades. Heads bur-like; involucral bracts reduced to hooked bristles. Flowers tubular, red to pink. Central and eastern, rich uncultivated soil.

p188 *Artemisia*, Wormwood. Several species, annuals or perennials, usually with pinnately compound or dissected leaves, frequently densely gray-hairy, usually strong-scented. Heads small, in diffuse branched inflorescences or in axils of reduced upper leaves, without ligulate flowers, yellowish to green. Roadsides, pastures, locally common. The sagebrush of arid ranges, deserts and mountains is a shrubby species of *Artemisia*.

p193 *Carduus. Carduus nutans*, Musk thistle. Plants biennial with a leaf rosette the first year, producing a stem the second season. Leaves and stems spiny, the leaf divisions contacted into intricate patterns. Heads solitary, long stalked above the leaves, larger than those of any other thistles, up to 5 cm. in width, often bent over or recurved. Pastures and waste areas, of sporadic occurrence, but apparently becoming more abundant. Flowering in late June. Aside from its weedy characters, this thistle is a very striking and interesting plant.

Centaurea, Star thistles, Knapweeds. Plants usually gray-pubescent with cobwebby hairs. Lower leaves often pinnatifid; upper toothed or entire. Heads entirely of tubular flowers, lavender to purple, less frequently yellow.

p189 *Centaurea maculosa*, Spotted knapweed. Plants biennial. Involucral bracts toothed at top. Achenes dark in color, with a basal notch; pappus present and conspicuous. Occasional in much of range, more common northeast, uncultivated soil.

Several species of *Centaurea* are sporadic in the North Central States. Most of them are similar to *C. maculosa* with respect to the description above and contrast with *C. repens* (below). One species, *C. solstitialis*, has yellow flowers and spiny heads.

p189 *Centaurea repens*, Russian knapweed. Plants perennial from creeping roots. Involucral bracts nearly entire. Achenes without a basal notch, plump, smooth or slightly longitudinally ridged, gray-white. Pappus not present on mature seeds. Primary noxious or prohibited in all states but of significant abundance only in extreme western areas. Extremely persistent in both cultivated and noncultivated soil in arid areas.

Cirsium, Thistles. Plants erect. Stems and leaves spiny. Heads (in our species) lavender or purple, consisting entirely of tubular flowers. Seeds smooth, slightly flattened, with a very conspicuous pappus of fine bristles.

p190 *Cirsium altissimum*, Field thistle, Tall thistle. Plants biennial; stem developing from a leaf rosette, becoming 1.5-3 m. tall. Leaves irregularly divided into toothed lobes or nearly entire, whitish-hairy beneath, not extended downwards on stem. Heads purple, 3-4 cm. across, upper bracts not spiny-tipped. Seeds 5-6 mm. long, brownish streaked or blotched on a light background, with a wide yellow rim at the apex. Abundant, fields, pastures, waste places. Summer.

Cirsium arvense, Canadian thistle. Plants perennial from creeping roots, not rosette forming, usually not exceeding 1 m. in height. Leaves irregularly lobed or toothed. Heads lavender, smaller than those of other thistles, 1-2 cm. across. Seeds about 3 mm. long, yellowish-brown, with an inconspicuous yellow rim at apex. Primary noxious or prohibited in all states but of principal significance in northern section. Nearly all habitats, cultivated and uncultivated areas alike, usually fertile soil. Seeds occasional in legume, grass and small grain seed. p191

Much of the Canadian thistle never produces seed. The species is dioecious; some plants are entirely pistillate, and others staminate. The plants in a given patch or even an extensive area are frequently all descended from the root system of the same individual, hence are all of the same sex. Seed will not be set unless both staminate and pistillate plants are in the same vicinity.

Cirsium vulgare (C. lanceolatum), Bull thistle. Plants biennial, 1-2 m. tall. Leaves pinnately lobed, mostly divided into oblong-lanceolate untoothed divisions, not white-woolly beneath; narrow sections of blades frequently extend downwards on the stem below node. Heads 3-4 cm. across; involucral bracts all prickly. Flowers purple. Seeds 4-5 mm. long, black-streaked or blotched upon an ivory background with a narrow yellow rim at the apex. Abundant, central and eastern; pastures, roadsides, waste places. Middle and late summer. Seeds occasional in legume and grass seed. p190, p192

Eupatorium, Boneset, Thoroughwort, Joe-Pye weed. Several perennial species with toothed, opposite or whorled leaves. Heads relatively small, of tubular flowers, white to purple. Achenes small, black, longitudinally ridged, with a pappus of numerous fine hairs. Primarily pasture weeds, most common in South and East. One species *(E. rugosum*, white snakeroot) generally grows in woodlands and is poisonous. p194

Gnaphalium. *Gnaphalium obtusifolium*, Cudweed. Annual or biennial. Plant white from dense mottled pubescence. Stem leaves sessile, narrowly oblong, entire. Heads numerous, small, of white tubular flowers. Achenes minute. Pastures and waste areas. Eastern. p195

Vernonia, Ironweeds. Plants tall. Leaves lanceolate, serrate. Heads numerous, at the end of branched stems, red-purple. Flowers all tubular. Achenes black, longitudinally ribbed, with a pappus of short bristles or scales. Southern portion; pastures. Summer. p196

FLOWER HEADS WITH MARGINAL LIGULATE FLOWERS AND A CENTRAL DISK OF TUBULAR FLOWERS

Achillea. Achillea millefolium, Yarrow. Plants perennial from creep-
p197 ing rootstocks, erect, or when occurring as a weed in lawns, prostrate. Leaves dissected into fine divisions, fern-like. Heads small, 3-4 mm. across, whitish; ligulate and tubular flowers both present. Seeds small, 2-3 mm. long, with longitudinal white and black lines; pappus inconspicuous. Relatively common, more abundant eastward. Pastures, grassland, roadsides, yards. Summer. Seeds common in agricultural seed of timothy and redtop.

p197 *Anthemis. Anthemis cotula*, Mayweed, Dog-fennel, Stinkweed. Plant annual, erect, strong-scented. Leaves pinnately dissected. Heads solitary at stem apices, with white, ligulate flowers and yellow tubular flowers. Achenes about 2 mm. long, thick, longitudinally ribbed and warty, light brown in color; pappus not present. Locally common, legumes, roadsides, pastures, around buildings and feed lots. Summer. Seeds common in forage grass seed and legumes.

p198 *Aster*, Asters. Plants perennial, usually from rootstocks. Leaves petioled or sessile, toothed; in some species the lower ones cordate. Tufts of crowded secondary leaves are often present in axils of main stem leaves. Heads numerous, in diffuse, terminal inflorescences, with yellow tubular flowers and blue to white ligulate flowers. Achenes very small with a pappus of thread-like bristles. Several species, on uncultivated soil or prairie remnants, not important as weeds, but frequently conspicuous in fall. Central and east.

p199 *Bidens*, Spanish needles, Beggar's-ticks. Plants annual. Leaves opposite, simple or pinnately dissected or compound. Heads with yellow tubular and ligulate flowers or sometimes ligulate portion absent. Achenes flattened or quadrangular; pappus of 2 to 4 stiff awns with fine, recurved bristles, these readily adhering to clothing or the hair of animals. Mostly eastern, locally abundant. Pastures, uncultivated areas. Several species.

p199 *Chrysanthemum. Chrysanthemum leucanthemum*, Oxeye daisy. Perennial. Leaves pinnatifid or toothed. Heads solitary at stem tips, large, with white ligulate flowers and a disk of yellow tubular flowers. Achenes dark with lighter longitudinal ridges. Northeast. Pastures and uncultivated areas, locally very abundant. The seeds occur in those of various forage grasses.

Coreopsis. Coreopsis tinctoria, Tickseed. Annual. Leaves pinnately compound or pinnatifid with slender, linear segments. Ligulate flowers orange-yellow; tubular flowers purple-brown. Southwestern, in uncultivated areas, locally abundant. Summer.

p200 *Erigeron.* Annuals or biennials. Lower leaves toothed or lobed, upper usually nearly entire. Heads of both ligulate and tubular flowers; the former white; the latter yellow.

Erigeron canadensis, Horseweed. Plants annual, erect, up to 2 m. in height, unbranched below inflorescence. Stems densely p200
leafy, the blades sessile and entire. Heads small, 4-5 mm. across, panicled, whitish; ligulate flowers inconspicuous. Seeds very small, 1 mm. in length, light brown with a pappus of fine bristles. Abundant, fields, pastures, roadsides. Late summer. Occasional in grass seed.

Erigeron spp., Daisy fleabane. Several species (*E. annuus* p201
perhaps the most common) which contrast with the above in usually being branched, and having conspicuous aster-like heads, i.e. white rays and a yellow center. They may be distinguished from asters in that they are not perennial and lack the axillary leaf tufts usually characteristic of the latter. Pastures and roadsides, thickets, waste areas in towns. Summer.

Grindelia. *Grindelia squarrosa*, Gumweed, Tarweed. Short-lived perennial. Entire plant sticky or gummy. Leaves sessile and somewhat p201
clasping, oblong, serrate. Heads with yellow ligulate and tubular flowers. Achenes yellowish, angular, somewhat curved; pappus of a few, quickly lost bristles. Western, mostly uncultivated soil, a variety of habitats.

Helenium, Sneezeweed, Bitterweed. Ligulate flowers yellow, toothed at tip. Tubular flowers forming a conspicuous brown or yellow disk. Achenes with hairy ribs; pappus of a few bristle-tipped scales.

Helenium autumnale, Sneezeweed. Leaves toothed. Heads large and conspicuous. Rays drooping. Disk hemispheric, p202
greenish-yellow. Mostly sporadic in occurrence, wet areas in pastures and along ditches. Poisonous.

Helenium tenuifolium, Bitterweed. Stems densely leafy with sessile linear-filiform blades. Heads yellow. Southern only. p203
Pastures, waste areas, around buildings. When eaten by cattle, the plant taints the milk with a disagreeable taste. Summer.

Helianthus, Sunflowers. Annuals or perennials, usually tall, coarse plants. Leaves opposite or alternate, ovate to lanceolate, entire or p204
toothed. Heads large, with both ligulate and tubular flowers, the former yellow, the latter yellow or brown. Achenes oblong to obovate, often longitudinally striate; pappus of inconspicuous, quickly dehiscent scales.

Sunflowers of diverse kinds occur throughout the North Central States, and are often sufficiently abundant to contribute materially to the characteristic late summer landscape. Some are locally important weeds in cultivated soil, but for the most part they occur along roadsides, ditches, railroad rights-of-way, untilled waste areas, and prairie remnants.

Solidago, Goldenrod. Plants perennial. Heads numerous, small, often mostly borne only on one side of flowering stalks. Both ligulate and p204
tubular flowers present, yellow. Achenes small, with numerous capillary bristles. Roadsides, pastures, prairie remnants, scarcely weedy but frequently very conspicuous in the fall.

PLATE 101

Ambrosia elatior 1. "Seed" – involucre enclosing fruit x4. 2. Inflorescence x1/2. 3. Basal leaf x2/3.

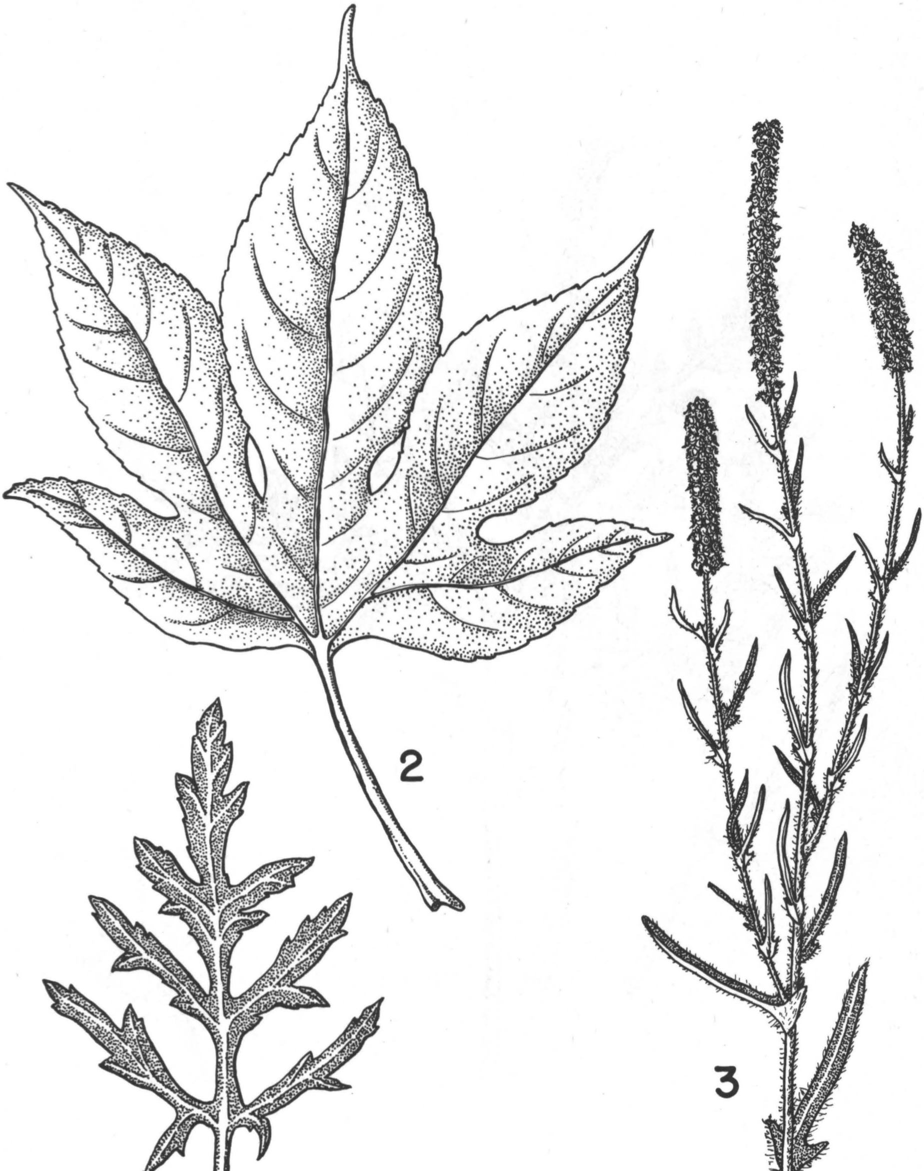


PLATE 102

Ambrosia psilostachya 1. Leaf x2/3.
Ambrosia trifida 2. Leaf x2/3.
Ambrosia bidentata 3. Apex of plant x2/3.

PLATE 103

Franseria discolor Flowering branch x2/3.

PLATE 104

Iva axillaris 1. Flowering branch x2/3.
Iva xanthifolia 2. Leaf and fragment of inflorescence x1/3.

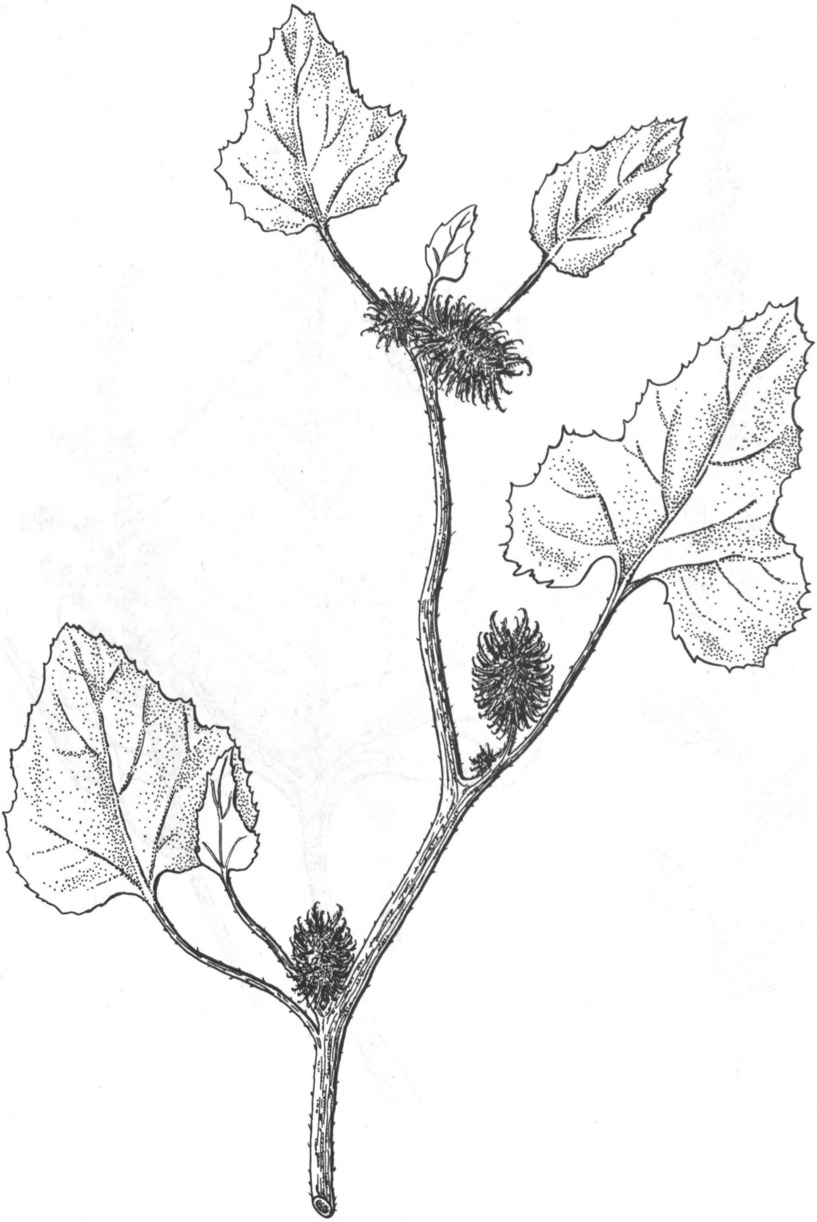


PLATE 105

Xanthium strumarium Fruiting branch x2/3.

PLATE 106

Cichorium intybus 1. Basal leaf x2/3. 2. Branch of inflorescence x2/3.

PLATE 107

Hieracium aurantiacum Habit x2/3.

PLATE 108

Lactuca scariola Stem apex of young plant x2/3.

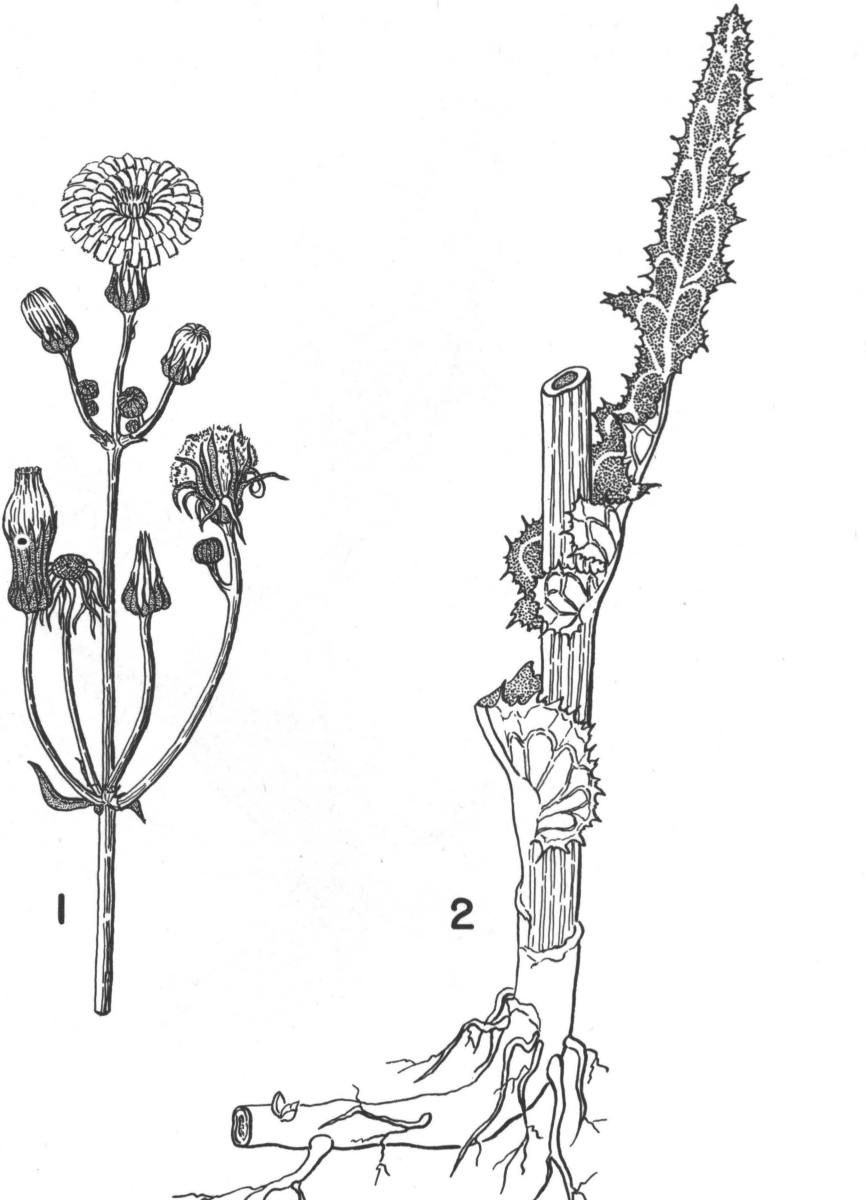


PLATE 109

Sonchus arvensis 1. Portion of inflorescence x2/3. 2. Basal leaf and root x2/3.

PLATE 110

Sonchus oleraceus Apex of stem x2/3.

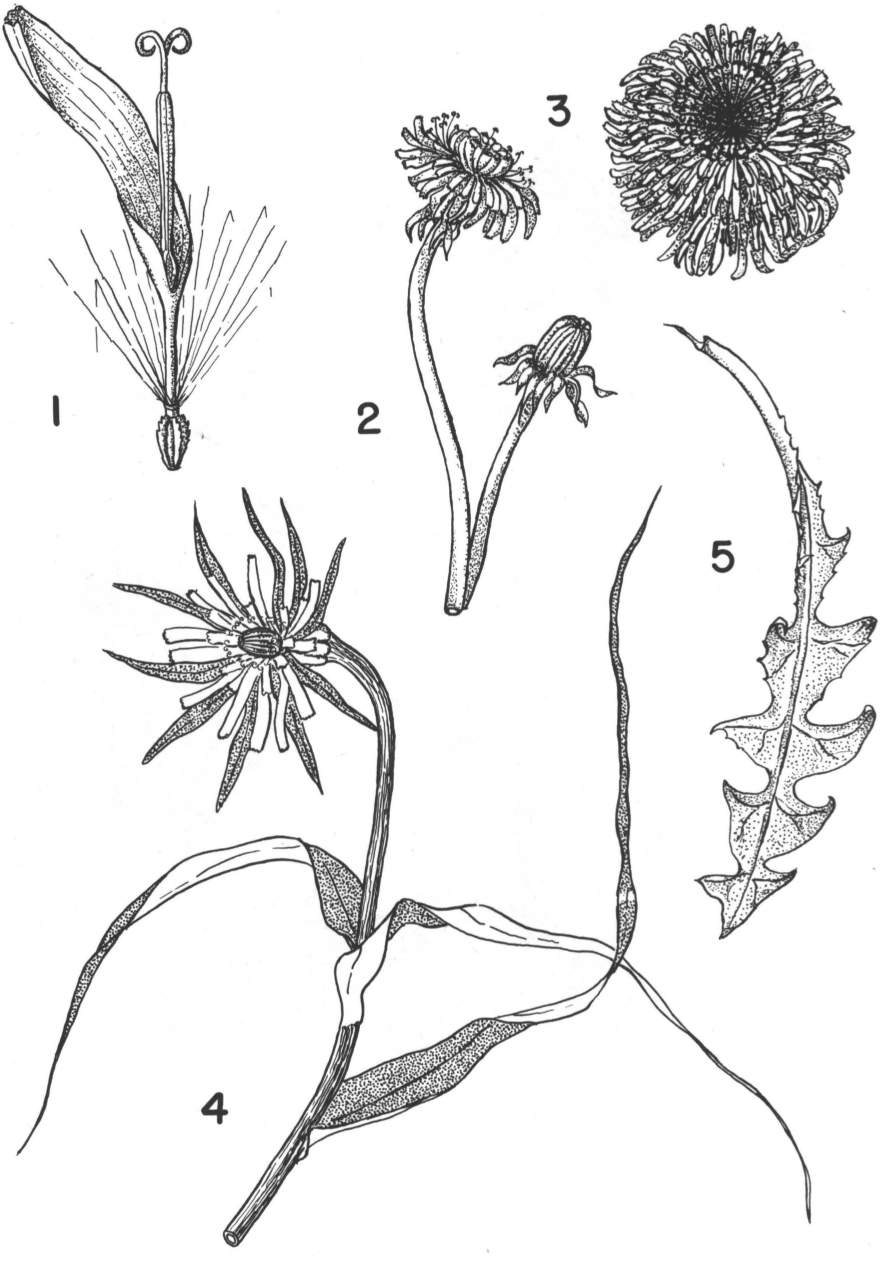


PLATE 111

Taraxacum officinale 1. Enlarged flower x4. 2. Flower heads x2/3. 3. Flower head, top view x1. 5. Leaf x2/3.
Tragopogon dubius 4. Head and leaves x2/3.

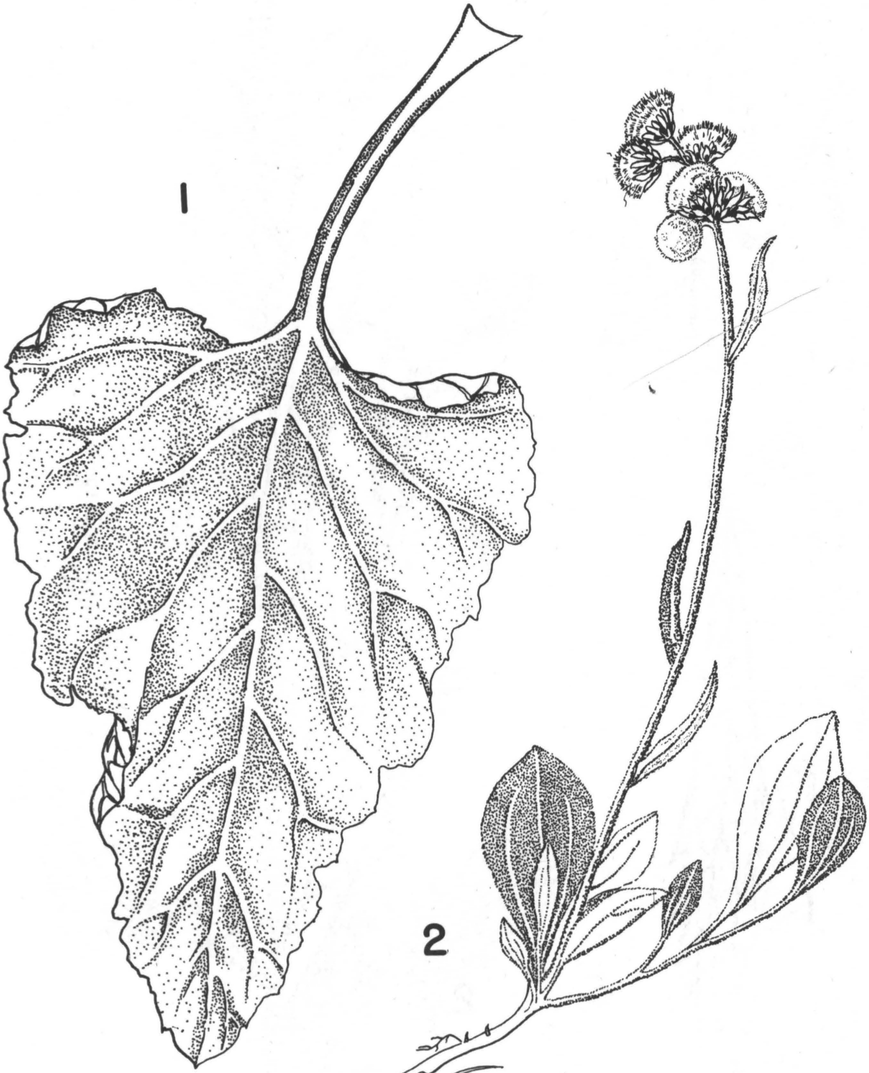


PLATE 112

Arctium minus 1. Leaf x1/2.
Antennaria plantaginifolia 2. Habit x2/3.

PLATE 113

Artemisia ludoviciana 1. Basal leaf x2/3. 2. Inflorescence x2/3.

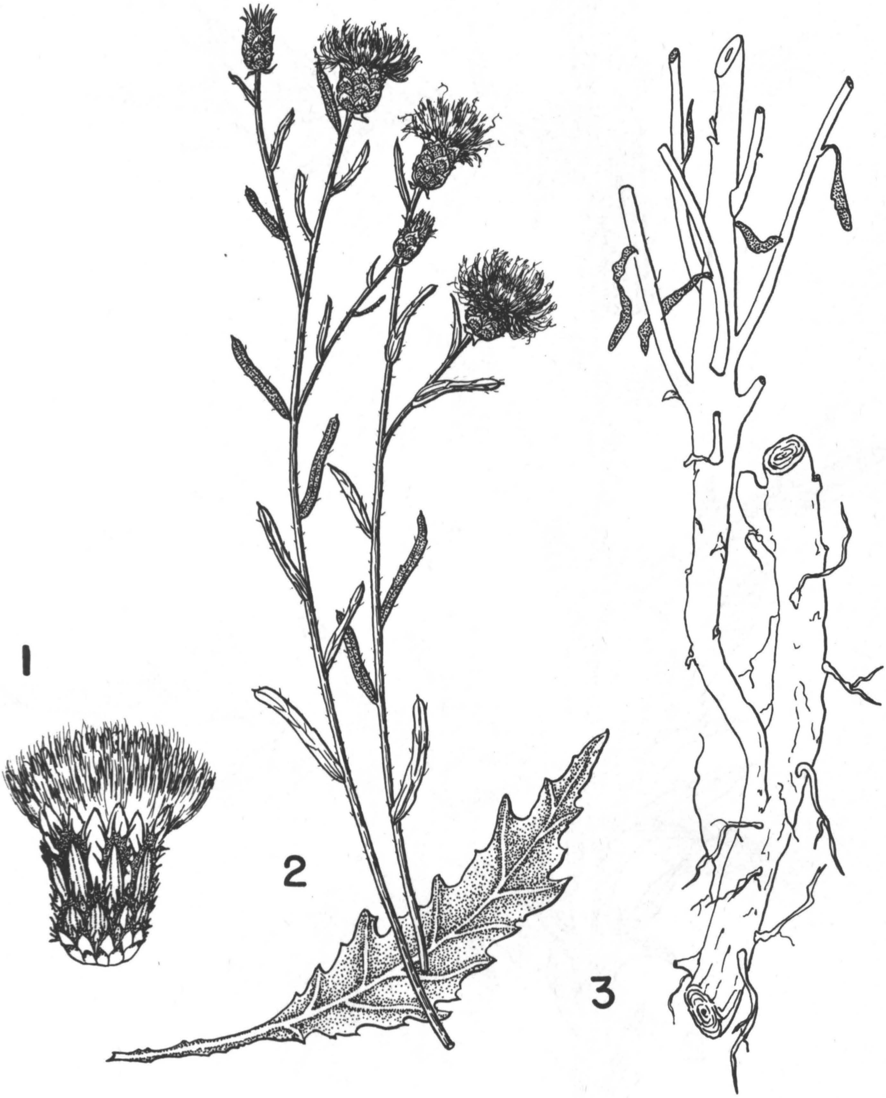


PLATE 114

Centaurea maculosa 1. Flower head x1 1/3.
Centaurea repens 2. Inflorescence and basal leaf x2/3. 3. Perennial root x2/3.

PLATE 115

Cirsium vulgare 1. Stem leaf x1/3.
Cirsium altissimum 2. Portion of stem x1/2.

PLATE 116

Cirsium arvense 1. Inflorescence x2/3. 2. Young plant x2/3.

PLATE 117

Cirsium vulgare 1. Head x2/3. 2. Rosette x1/3.

PLATE 118
Carduus nutans Head and leaf x1/2.

PLATE 119

Eupatorium purpureum Inflorescence x1/3.

PLATE 120

Gnaphalium obtusifolium Apex of plant x2/3.

PLATE 121

Vernonia crinita Apex of plant x2/3.

PLATE 122

Anthemis cotula 1. Ligulate flower x2. 2. Tubular flower x4. 3. Heads and leaves x2/3.
Achillea millefolium 4. Apex of plant x2/3.

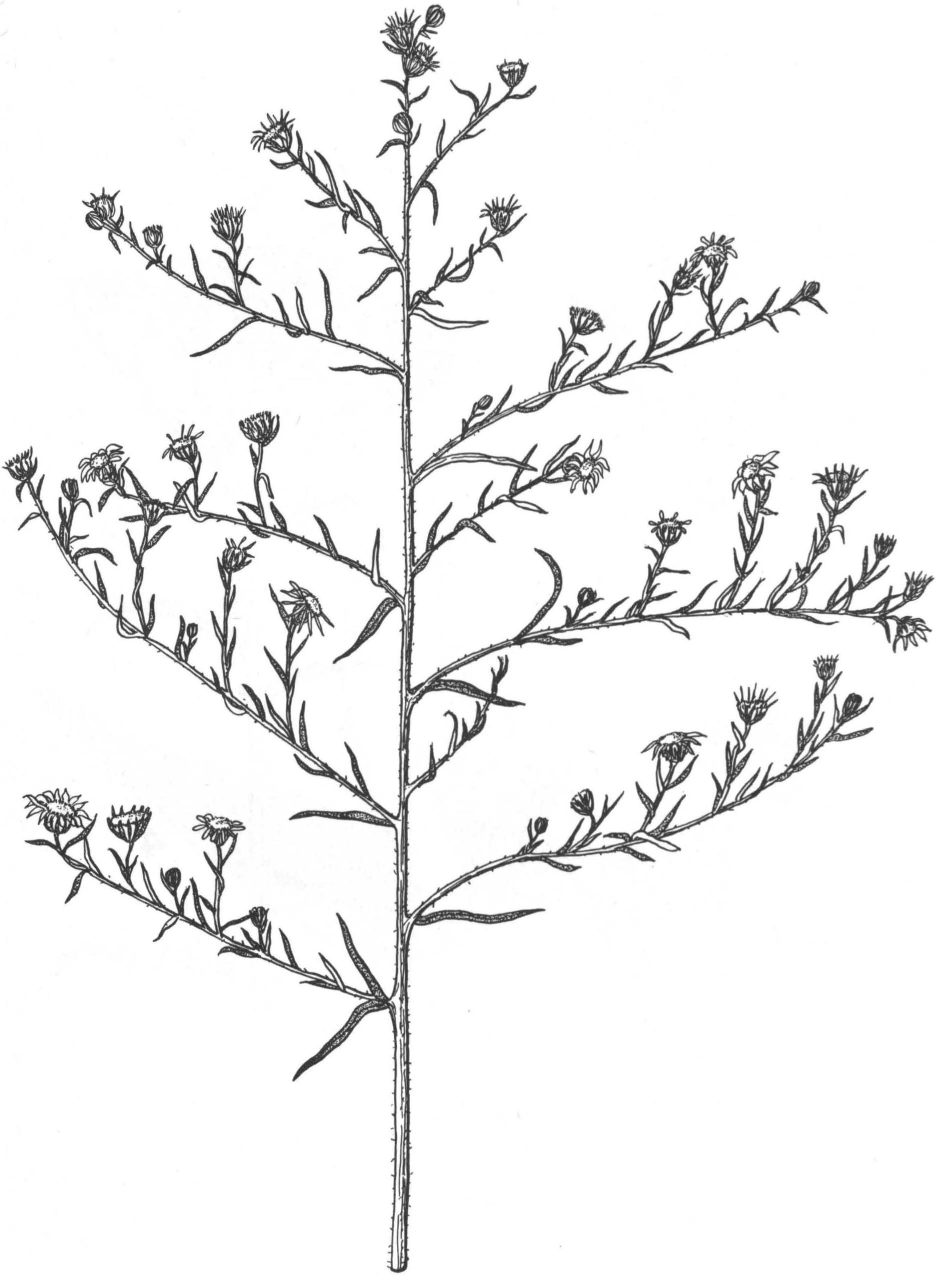


PLATE 123

Aster pilosus Inflorescence x1/2.

PLATE 124

Bidens bipinnata 1. Inflorescence fragment and leaf x2/3.
Chrysanthemum leucanthemum 2. Apex of plant x2/3.

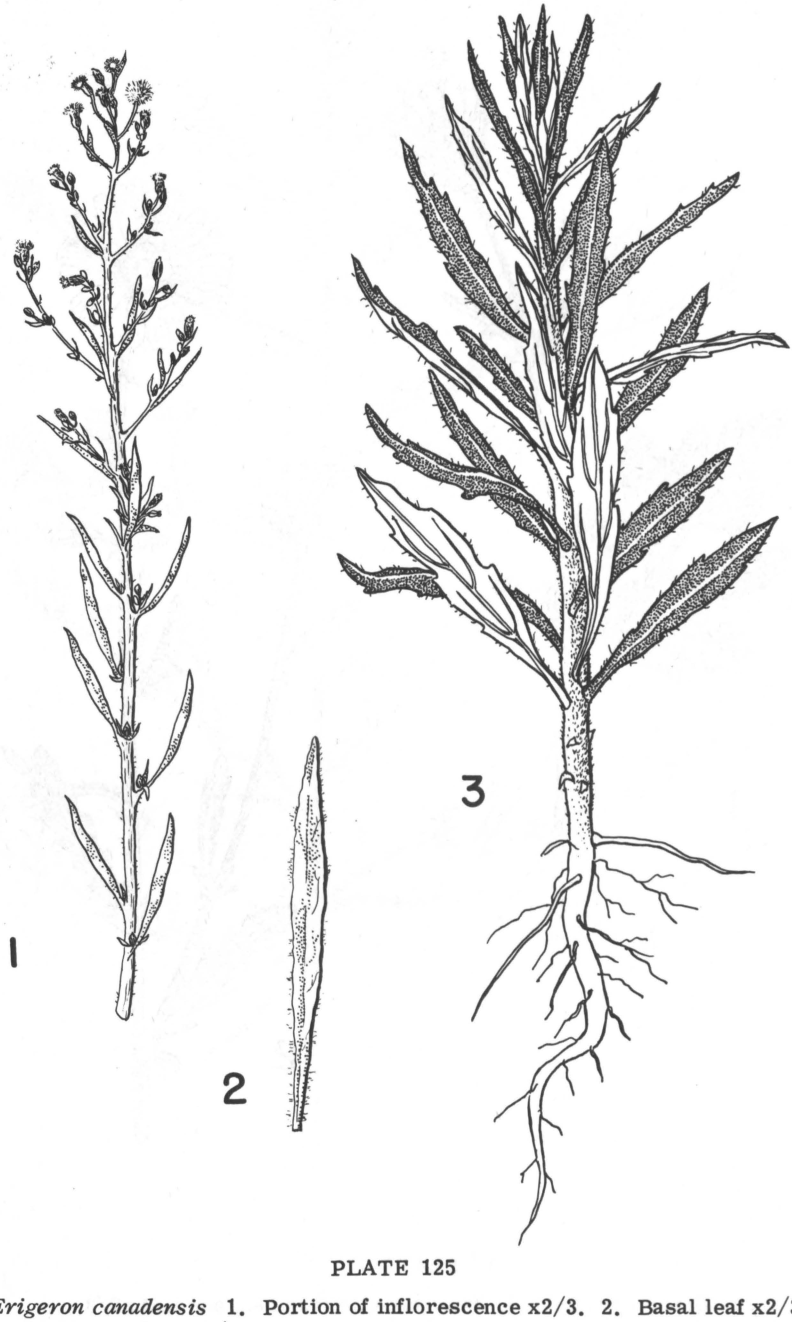


PLATE 125

Erigeron canadensis 1. Portion of inflorescence x2/3. 2. Basal leaf x2/3. 3. Young plant x2/3.

PLATE 126

Grindelia squarrosa 1. Habit x2/3.
Erigeron annuus 2. Basal leaf x2/3. 3. Portion of inflorescence x2/3.

PLATE 127

Helenium autumnale Habit x2/3.

PLATE 128
Helenium tenuifolium Habit x2/3.

PLATE 129

Solidago missouriensis 1. Habit x2/3.
Helianthus annuus 2. Head and leaves x1/4.

18. The Gramineae, Grass Family

PLANTS with hollow, round or flat stems (culms). Leaves arranged in two rows on opposite sides of the stem, consisting of three parts: (1) sheath, (2) ligule, (3) blade. The sheath is the basal portion enclosing the stem above the node in tube-like fashion; it is not, however, in most genera, a closed tube but usually possesses free lateral edges which overlap. The ligule is a little collar on the upper side of the leaf at the juncture of the sheath and the blade. The blade is entire, linear, and parallel-veined. The flowers consist of a pistil and three stamens. Each flower is enclosed by a pair of unequal bracts, one on each side. The larger of these bracts is the lemma, the smaller the palea. The unit consisting of the flower, lemma, and the palea is the floret. The florets are arranged in spikelets, each of which consists of a central axis, a pair of bracts (glumes) at the base, and one to several florets above. Fruit, a grain or caryopsis, 1-seeded, the fruit coat permanently adherent about the seed. The grain may be oblong with a longitudinal furrow, boat-shaped, ovoid or planoconvex. The seed contains abundant endosperm and a small embryo at the basal end. The outlines of the embryo are visible externally through the fruit coat.

Grasses are sometimes confused with other grass-like monocotyledonous plants, particularly the sedges or slough grasses (Cyperaceae) and the rushes (Juncaceae). The common sedges found on or about agricultural land have solid, triangular stems with leaves arranged in three rows. The leaf sheath forms a closed tube about the stem. The flowers are in spikes or spikelets but are not enclosed by a pair of bracts; they are usually in the axil of a single bract. In the most common sedges (*Carex* spp.) the 1-seeded fruit is enclosed by a bladdery, beaked, sac-like structure. The common rushes have rounded stems and closed sheaths; the leaves are usually narrow and wiry. The flowers have greenish sepals and petals; the fruit is a small, many-seeded capsule.

The shape and texture of the lemma, palea, and glumes differs widely in various grasses. These structures may be thin and papery, or thick and bone-like. The glumes and lemmas of certain grasses bear long apical bristles, awns.

Grasses differ from one another most conspicuously in the nature and arrangement of their spikelets. Three types of spikelets are most common among weed and crop grasses: (1) Spikelets possessing several florets, the overlapping lemmas of which give them a shingle-like appearance. At maturity the spikelet breaks up into seedlike units, each consisting of a single floret. Examples: bromegrasses *(Bromus)*, quackgrass *(Agropyron)*. (2) Spikelets possessing one floret; lemma and palea thin and papery. At maturity the floret usually separates from the glumes. Example: timothy *(Phleum)*. (3) Spikelets with one fertile floret, bearing below it a sterile lemma (having no flower) as well as a pair of glumes. Glumes and sterile lemma papery; fertile lemma and palea much hardened and closely adherent about the seed. The whole spikelet breaks off as a seed-like unit at maturity. Examples: barnyard grass *(Echinocloa)*, witchgrass *Panicum*.

The spikelets may be borne in open panicles (witch grass, bromegrasses) in condensed-spike-like panicles or racemes, (foxtail grasses; *Setaria*), in solitary terminal spikes, (quackgrass; *Agropyron*), or in digitate clusters of spikes — several spikes originating from the same point in finger-like fashion, (crabgrass; *Digitaria*).

In wheat, rye, hulled oats, or timothy, the structure popularly called the seed is the 1-seeded grain. In other grasses the "seed" is the grain plus certain persistent enveloping floret and spikelet structures. The nature of these structures depends upon the manner in which the spikelet breaks or separates from the parent plant at maturity. In spikelet type (1), as described in the paragraph above, the seed is the matured floret, that is, grain surrounded by lemma and palea plus a short segment of the spikelet axis, the rachilla, which is attached at the base of the seed and upwardly directed on the palea side. In type (2) it consists of the floret alone or of the entire spikelet if the seed is "stripped" before full maturity. In type (3) the seed consists of the entire matured spikelet. Seeds of types (2) and (3), from 1-flowered spikelets, do not possess a rachilla.

Grass "seeds" may assume various guises depending upon the stage when harvested and upon the action of cleaning machinery in stripping off enveloping structures (i.e. lemma, palea, glumes). For example, quackgrass seeds may be observed as: (a) the entire spikelets (usually in small grains), (b) a floret, the grain, surrounded by lemma and palea and bearing a rachilla, (c) a dehulled grain. Yellow foxtail "seeds" may consist of: (a) a dehulled grain, (b) grain plus lemma and palea, (c) grain plus lemma, palea, a sterile lemma, and glumes. Unhulled or virgin redtop consists of entire spikelets, grain surrounded by glumes, lemma and palea. Processed redtop is usually a mixture of unhulled seed (surrounded by lemma and palea) and hulled grains. Commercial timothy seed likewise contains both unhulled seed (possessing lemma and palea) and hulled grains which have been stripped from their enveloping structures.

The grasses contain more species of weeds than any plant family except for the Compositae, and are probably more important because of the overwhelming abundance of many of the kinds. Their relative importance is, futhermore, increasing due to the fact that they are not killed by the most widely used herbicides, 2,4-D and relatives. In many instances, the destruction of dicotyledonous weeds has only resulted in grassy species taking their place. Farmers tend to think of weeds as consisting of two general kinds, i.e. grassy weeds and broad-leaved kinds.

Although the grasses include many weeds, they are most important of all plants as regards the welfare of man. More than half of the world's cultivated land is devoted to grasses, primarily the cereal crops and corn. The millions of acres of permanent pasture and range are dominated by grasses. Grasses serve directly as human staple foods (wheat and rice most important) and as food for domestic animals (forage and grain) upon which our meat and dairy industries are based. Grasses provide the background, the lawn, for all home and urban ornamental plantings.

In a large family like the grasses, a subordinating classification is a necessity. The group is conventionally divided into a series of tribes which, roughly, are believed to represent natural (i.e. composed of related members) categories. This classification is based upon technical characters of the spikelets which it is beyond the scope of this text to consider. The following arrangement of grasses into groups is, therefore, purely one of convenience. However, it brings together into smaller units those grasses having certain characters in common and should be useful as a learning aid.

SPIKELETS FORMING SPINY BURS

Cenchrus. *Cenchrus pauciflorus*, Sandbur. Annual, prostrate or spreading. Inflorescence a short spike of spiny burs, each bur containing two p216 spikelets and seeds. Burs indehiscent, the grains (yellowish, planoconvex) not often seen. Locally abundant, gardens, roadsides, waste areas. Summer and fall. This annual grass is particularly annoying because of its spiny burs which are difficult to remove from clothing, and which will readily puncture the skin.

INFLORESCENCE A SPIKE OR APPEARING AS SUCH

Inflorescence: (1) a single terminal spike, or (2) a cylindrical condensed panicle which is spike-like in appearance, e.g. foxtails *(Setaria)*, or (3) a digitate cluster of spikes at apex of stem, e.g. crabgrass *(Digitaria)*. Not included here are grasses in which the parts of a compound inflorescence appear spike-like, or those which have a series of racemes or spike-like branches extending up the stem.

Agropyron, Quackgrass and Wheatgrasses. Plants perennial, erect. Leaves at juncture of sheath and blade with lateral projections, (auricles) which tend to clasp about the stem. Spikelets in narrow terminal spikes, one at each node of spike (compare with *Elymus* and *Hordeum*), 4- to 12-flowered, placed flatwise to main axis of spike (contrast with *Lolium*). Seeds usually the matured florets, these boat-shaped, 7-9 mm. long with or without a short awn.

The auricle, characterized above, is not specific to *Agropyron* alone, but of those grasses in which the inflorescence is a true spike. This group, the tribe Hordeae, includes the following genera: *Elymus*, *Triticum*, *Secale*, *Aegilops*, *Hordeum*, and *Lolium*.

Agropyron repens, Quackgrass. Plants spreading by exten-
p216 sively creeping scaly rootstocks. Leaves greenish, tending to bend over at tips, not rolling up when dry. Spikelets 4- to 8-flowered. Seeds frequently confused with those of western wheatgrass (*A. smithii*; compare below), differing as follows: (1) rachilla not enlarged towards apex, (2) a lateral bulge is present on back of lemma at base of seed, (3) callus (tissue surrounding basal attachment scar) glabrous, (4) palea surface usually glabrous.

Primary noxious or prohibited in all northern states. Spring and summer.

Succeeding best in cool, moist climate, quackgrass is of major significance from Minnesota and Iowa, eastward, and from central Iowa, northward. In much of this area it is perhaps the most common primary noxious weed. The plant is of common occurrence elsewhere in the North Central States but its importance as a weed progressively diminishes to the South and West.

Quackgrass is similar to, and not infrequently confused with, western wheatgrass, the ryegrasses (*Lolium* spp.), and wild rye (*Elymus* spp.). Western wheatgrass is described immediately below on a comparative basis. *Lolium* spp. possess spikelets whose narrow edge lies against the rachis and do not have the creeping rhizomes characteristic of quackgrass. The genus *Elymus* is characterized by spikelets which are two or more at each node, whereas those in *Agropyron* are solitary. In vegetative condition, quackgrass may be confounded with rhizomatous forage grasses, e.g. smooth brome *(Bromus inermis)*. In such instances the presence of the auricle on the quackgrass leaf will serve to distinguish it from the crop plants.

The seeds of quackgrass are very similar to those of western wheatgrass *(Agropyron smithii)*, slender wheatgrass *(A. trachycaulum)*, and wild rye *(Elymus virginicus)*. Western wheatgrass seeds are described below. Those of slender wheatgrass seeds usually have a silky-hairy rachilla and tend to flare out at the tip (thus appear broader than those of quack). The palea of wild rye seeds usually exceeds the lemma in length.

Agropyron smithii, Western wheatgrass, Bluestem. Plants with
p216 short rootstocks, not spreading aggressively. Stems and leaves blue-green to glaucous-green. Leaves stiff and wiry, tending to roll up when dry. Spikelets 8- to 12-flowered. Seeds differing

from those of quackgrass (compare above) as follows: (1) rachilla slightly enlarged towards apex, (2) a lateral notch or indentation present on back of lemma near base of seed, (3) callus pubescent on lateral margins, (4) palea surface usually finely hairy. Locally common, roadsides, pastures. Early summer. Seeds common in forage grass seed shipped from the West.

Lolium. *Lolium perenne*, Perennial ryegrass. Plants perennial, 3-7 dm. tall, glabrous. Spikelets 10-13 mm. long, several-flowered but with only one glume, in narrow terminal spikes, with the narrow edge of the spikelet lying against the stem axis. "Seed" the matured floret, 5-7 mm. long, awnless. Cultivated, lawns and pastures; sparingly escaped. p217

The seeds are somewhat similar to those of quackgrass but are wider and flatter; the outlines of the dark grain show through the palea; the rachilla is somewhat flattened; the back of the lemma possesses a conspicuous, narrow crease just above the callus.

Annual ryegrass *(Lolium multiflorum)* is similar to the perennial species except that it is awned and usually does not persist over one year.

Elymus, Wild rye. Tall perennial grasses with spikelets paired at each node in dense bristly, spikes; glumes and lemma short- or long-awned. Summer. Common, roadsides, fence rows, and uncultivated areas. p217

Hordeum, Barley. Inflorescence a terminal spike. Spikelets usually 3 at each node of the spike axis, the central one sessile and fertile, 1-flowered; the lateral ones stalked and sterile except in 6-rowed barley.

Hordeum jubatum, Squirrel-tail grass. Plants erect, to 6 dm. in height, perennial. Sterile spikelets reduced to a cluster of thread-like awns, 2-5 cm. in length; glumes of fertile spikelets awned; inflorescence having the appearance of a dense silky plume. Each group of three adjoined spikelets separates as a unit at maturity. Abundant, and frequently contributing a silvery cast to pastures, roadsides, and waste places; rarely seen in cultivated fields. Summer. p218

Hordeum pusillum, Wild barley. Plants annual, usually not more than 2-3 dm. long. Spikes dense, with short stiff awns. Southern. Pastures, hayfields, waste areas. p219

Hordeum vulgare, Barley. Plants annual, erect, to 1 m. or more. Glumes and lemmas drawn out into stiff awns, or awnless (beardless barley). Commercial barley seed consists of the matured floret, the grain enclosed by the close fitting lemma and palea; the awn is usually broken off. Floret yellowish, 10-12 mm. long, narrowly ovoid, irregularly wrinkled. Cultivated, occasionally escaped along roadsides. p219

Secale. *Secale cereale*, Rye. Plants annual, erect. Inflorescence a terminal, bristly, slightly drooping spike. Spikelets two-flowered. Glumes inconspicuous, narrowly lanceolate. Lemmas long-awned, bristly on the p218

back of midrib. Grain 6-9 mm. long, oblong, slightly higher than thick, longitudinally channeled, usually a glazed brown in color. Commercial rye seed consists of the hulled grains.

p220 *Triticum*, Wheat, Erect annuals. Inflorescence a dense terminal spike which is generally somewhat shorter than that of rye and stiffly erect. Spikelets 2- to 4-flowered. Glumes broadly ovate. Lemmas thick, lop-sided, awned or unawned. Grains short-oblong, 7-9 mm. long, longitudinally furrowed, red-brown to straw-brown in color, similar to those of rye but thicker and with embryo flat. Commercial wheat seeds are the hulled grains.

p220 *Aegilops*. *Aegilops cylindrica*, Goatgrass. Winter annual. Spikes slender, with the alternate spikelets fitting into grooves in the thickened, bony axis. Upper spikelets longer-awned than lower ones. Spike rachis segmenting at maturity into sections, each bearing a single spikelet. "Seeds" thus bony fragments comprising the spikelet plus a portion of spike axis. Southern. Winter wheat and waste areas. Spring and early summer.

Setaria, Foxtail grasses. The species described below are rapid-growing summer annuals, erect or basally prostrate. Inflorescence a dense, cylindrical, spike-like bristly panicle. Spikelets planoconvex, 1-flowered, with a sterile lemma, surrounded by a cluster of barbed bristles. Glumes and sterile lemma papery; fertile lemma and palea thick and hard, roughly striate or corrugated. Grain planoconvex, greasy greenish-yellow. "Seed" the entire spikelet or portion of it.

p222 *Setaria lutescens*, Yellow foxtail. Spike tawny-yellow in color, scarcely drooping. Spikelets 3 mm. long, broadly ovate in outline; glumes about half as long as spikelet; lemma brown, coarsely cross-wrinkled. Abundant, cultivated areas, legumes, gardens, waste areas. Summer and fall. The seeds are common in those of legumes, oats, and soybeans.

p221 *Setaria viridis*, Green foxtail. Spike greenish in color, or straw-yellow when dead ripe, often drooping at top. Spikelets about 2 mm. long, ovate to narrowly ovate; second glume as long as the spikelet; fertile lemma straw-brown to dark chocolate, frequently dark-blotched upon a light straw background; surface of lemma granular, longitudinally striate or weakly cross-wrinkled. One of the most widespread and abundant late summer annuals. Cultivated soil, fields, gardens. The seeds are extremely abundant in red clover seed; also occur in small grain and grass seed.

p221 *Setaria faberii*, Tall foxtail, Giant foxtail. Similar to green foxtail, but often taller (sometimes 2 m.). Leaves finely hairy on upper surface. Spikes drooping at tip. Spikelets slightly larger than those of green foxtail; second glume somewhat shorter than fertile lemma. Primarily southern. Roadsides, cultivated land, legumes. Late summer.

p222 *Setaria verticillata*, Bristly foxtail. Spikes often irregular or lobed. Bristles backwardly barbed so that spikes will tend to cling to anything touching them. Spikelets similar to those of green foxtail. Waste areas, legumes.

Phleum. *Phleum pratense*, Timothy. Plants erect from a perennial p223 bulbous base. Inflorescence a congested panicle which appears like a dense cylindrical spike but without bristles as in the foxtails. Spikelets 1-flowered; glumes boat-shaped, short-awned, papery; lemma and palea thin; grain about 2 mm. long, plump-ovoid, minutely roughened on the surface, dull yellow in color. Cultivated. Most commercial seed consists of a mixture of grains enclosed in the lemma and palea, and hulled grains.

Digitaria, Crabgrasses. Plants annual, ascending or erect, much branched at base, the lower portion of the stem prostrate and rooting. Inflorescence a terminal cluster of digitate spikes. Spikelets plano-convex, with one fertile flower, maturing a single seed. Lemma and palea thick and hard, closely enclosing the grain; lemma finely striate. Sterile lemma and second glume (first glume minute) finely hairy, forming a papery covering about fertile lemma and palea. "Seed" the entire spikelet.

Digitaria ischaemum, Smooth crabgrass. Stems and leaves p223 glabrous. Spikelets (seeds) ovate in outline, 2.5 mm. long. Glume and sterile lemma as long as the spikelet. Fertile lemma black. Abundant, lawns, gardens, cultivated fields. Midsummer to fall. Seeds common in legume and grass seed.

Digitaria sanguinalis, Crabgrass, Large crabgrass. Stems p223 and leaves sparsely pubescent. Spikelets (seeds) narrowly ovate in outline, 3 mm. long. Glume about half as long as seed. Lemma olive-green when immature, brownish when mature. Abundant, lawns, gardens, cornfields. Midsummer to fall. Seeds occur in legume and grass seed.

Eleusine. *Eleusine indica*, Goosegrass. Annual, similar in appearance p224 to crabgrass but the digitate spikes considerably broader. Spikelets several-flowered. Grains readily shelling out, reddish-brown, cross-ridged. Primarily southern. Urban areas, waste ground, gardens, roadsides. Summer.

Cynodon. *Cynodon dactylon*, Bermuda grass. Perennial. Stems creep- p225 ing and rooting at nodes, with short, erect branches. Spikes digitately clustered as in crabgrass. Spikelets 1-flowered, pointed, sideways-compressed. Southern. A lawn and pasture grass mostly south of the north central range. As a weed, primary noxious or prohibited, cultivated and non-cultivated soil.

INFLORESCENCE BRANCHED; SPIKELETS SEVERAL-FLOWERED

Inflorescence a branched panicle, the spikelets usually well separated at branchlet tips, occasionally (e.g. *Dactylis*) crowded together in irregular clusters. Glumes usually much shorter than spikelets, the exerted lemmas overlapping in shingle-like fashion. *Avena*, in which the spikelet includes 2 or 3 florets enclosed by long glumes, comprises an exception to the above statement.

Except for *Eragrostis*, the "seed" in this group comprise a single, usually boat-shaped floret with a rachilla segment at the base. In *Eragrostis*, the seeds readily hull out of the spikelets.

Bromus, Bromegrasses. Plants erect. Leaf sheaths forming a closed tube. Spikelets large, several-flowered, in terminal panicles. Lemma notched at apex; awns, if present, arising from below this notch, not at tip. "Seed" a single floret, boat-shaped or flat.

p224 *Bromus inermis*, Smooth brome. Plants perennial, glabrous. Spikelets 2-2.5 cm. long. Seeds 8-10 mm. long, nearly flat, scarcely awned. Extensively cultivated; escaped along roadsides and in fields. Early summer.

p226 *Bromus japonicus*, Japanese brome. Plants annual, pubescent. Spikelets conspicuously awned. Seeds 7-8 mm. long (the awn of equal length), thin, strongly boat-shaped, the rachilla bowed with an oblique or vertical scar. Abundant, brome and grain fields, along roadsides, and in waste areas. Early summer. The seeds are common in commercial seed of smooth brome and other forage grasses.

p226 *Bromus tectorum*, Downy bromegrass. Plants annual, pubescent. Spikelets about 2 cm. in length, narrow, strongly awned, turning reddish-brown at maturity. Seeds 10-12 mm. long, narrow, bearing an awn of 15 mm. or more in length, finely hairy, flattened or boat-shaped. Abundant, pastures, roadsides, about houses and farm buildings. Late spring. Downy brome is in its "prime" two to three weeks before Japanese brome.

p227 *Bromus secalinus*, Cheat, Chess. Annual or winter annual. Plants and spikelets essentially glabrous. Mature florets thick and heavy, usually short-awned. Southern. Grains, forage grasses, roadsides. Considered a noxious weed in many states.

p227 *Festuca*, Meadow and Alta fescue. Erect perennials, with branching panicles. Spikelets large, essentially unawned. Lemmas not toothed at apex. Mature florets similar to those of ryegrass. Forage grasses, mostly of eastern portion.

p228 *Poa*. *Poa pratensis*, Kentucky bluegrass. Plants perennial from slender creeping rootstocks. Culms clustered, erect, glabrous. Inflorescence an open panicle. Spikelets several-flowered, 4-5 mm. long. "Seed" the matured floret plus rachilla, about 2.5 mm. long, boat-shaped. Cultivated, pastures and lawns.

Avena, Oats. Plants annual, erect, stooling from the base. Inflorescence a terminal panicle. Spikelets large, 2- or 3-flowered; glumes papery, as long as the spikelet. Awns arising from below tip of lemma.

The seed is the grain covered by the somewhat hardened lemma and palea.

Avena sativa, Oats. A cultivated crop. Spikelets mostly 2-flowered. Awns straight or absent. Lemmas essentially glabrous, usually light in color. p228

Avena fatua, Wild oats. Spikelets usually 3-flowered. Awns spirally twisted. Lemmas hairy, especially around basal scar, often dark in color. Northwest. Wheat and flax. p228

Eragrostis, Lovegrass, Stinkgrass. Plants annual, ascending. Spikelets panicled, many-flowered, conspicuously laterally flattened. Grain readily separating from lemma and palea, subspheroid, reddish-orange. Several species differing in size of spikelets. Common, gardens, roadsides, waste ground, around buildings. Late summer. p229

Dactylis. *Dactylis glomerata*, Orchard grass. Erect perennial. Spikelets in irregular, lopsided clusters at ends of panicle branches, about 3-flowered. Lemma and glumes finely hairy on dorsal nerves. A forage grass, mostly eastern portion. p229

INFLORESCENCE BRANCHED OR OF SEVERAL PARTS; SPIKELETS 1-FLOWERED

Inflorescence usually a branching panicle with spreading branches. Sometimes: (1) a series of essentially separate spikes or racemes, or (2) the branches somewhat appressed against main axis so that branching is inevident.

Agrostis, Redtop and Bentgrasses. Plants perennial, erect from rootstocks or prostrate. Spikelets in a diffuse terminal panicle, 1-flowered, small. Glumes papery. Lemma and palea very thin, slightly transparent, glossy. Grains ovoid, reddish-brown, about 1.5 mm. long. Cultivated and somewhat escaped. p231

Aristida. *Aristida oligantha*, Triple-awn grass. Low annuals. Panicles with relatively few spikelets. Spikelets 1-flowered, slender, the lemma with a very conspicuous, 3-branched awn. Southern. Pastures and waste areas.

Muhlenbergia. *Muhlenbergia schreberi*, Nimblewill. A fine-stemmed perennial from slender rootstocks. Leaves short, often diverging from stem at nearly a right angle. Panicles slender, the branches short and appressed against main axis. Spikelets small, narrowly elliptic, one-flowered, with a slender awn. Glumes and lemma papery. Central and southeastern. Shady, moist soil; in lawns under bushes and trees, around buildings, waste areas, not conspicuous but often very abundant. p230

Several other species of *Muhlenbergia*, usually larger, and with knotted, scaly rhizomes flourish in wet soil and sometimes invade cultivated land.

p231 *Andropogon*, Broomsedge, Bluestem. Perennials, often with flattened, erect stems in tufts. Inflorescences various, usually of several racemes or spikes, these clustered in various ways. Spikelets small, 1-seeded, often obscured by numerous filmy hairs which frequently give the entire inflorescence a feathery appearance.

Sorghum. Inflorescence a panicle. Spikelets borne in pairs, one large with a single floret and seed, the other smaller and sterile. Glumes thick. Lemma and palea very thin, difficult to discern. "Seed" the entire spikelet, usually with a pair of stalks (pedicels) appressed against the lower portion, or the hulled grain.

p232 *Sorghum halapense*, Johnson grass. A tall, leafy perennial from rank, creeping rhizomes. Spikelets becoming dark at maturity, narrowly ovoid, about 5 mm. long, the pedicels nearly equal in length, with cup-like tips. One of the major noxious weeds of the southern states, important in our range only in the extreme southern portion.

p232 *Sorghum sudanense*, Sudan grass. Similar to above in appearance but annual. Spikelets somewhat larger, 6 mm. long, usually straw-colored. Pedicels irregular in length, usually with jagged tips. A forage crop.

p233 *Sorghum vulgare*, Sorghum. Annuals. Panicles often dense and congested. Spikelets ovoid, larger than above, the plump grain often exposed at maturity. Pedicels similar to those of Johnson grass. Cultivated. The "seed" in most North Central States kinds is the hulled grain.

p233 *Echinochloa*. *Echinochloa crus-galli*, Barnyard grass. Plants lush, rapid-growing annuals. Stems prostrate to ascending, glabrous. Ligule absent. Spikelets in lopsided clusters (congested panicles), with one fertile flower and one seed, 3-4 mm. long exclusive of awns, broadly ovate, planoconvex. Fertile lemma and palea hard and thick, smooth and shining, yellowish in color. Glumes and sterile lemma papery, bristly on the outside. Awns present or absent. "Seed": (1) the entire spikelet, (2) the fertile lemma and palea enclosing the grain minus outside structures or, (3) the broadly ovate, yellowish grain. Common, fields, gardens, waste areas. Midsummer to fall. The seeds are abundant in agricultural seed.

Panicum, Panic grasses. Spikelets small, in panicles, 1-seeded, planoconvex. Fertile lemma and palea hardened, smooth and shiny, closely enclosing the grain. Glumes and sterile lemma papery. "Seed": (1) the entire spikelet, (2) the fertile floret or, (3) the hulled grain.

p234 *Panicum capillare*, Witchgrass. Plant a rapid-growing, rank annual, erect or spreading. Stems and leaves hairy. Panicle diffuse, becoming nearly as wide as high. Spikelets 2-3 mm. long, planoconvex, pointed, the first glume very short, the second glume and sterile lemma as long as the spikelet. Fertile lemma and palea shiny yellowish with fine longitudinal lines. Hulled grain planoconvex, yellowish. Very abundant, cultivated land. Late summer and early fall. Seeds common in commercial legume and grass seed.

Panicum dichotomiflorum, Fall panicum. Plants annual, spreading or ascending, rapid-growing. Stems and leaves glabrous. p235
Panicle narrower and less branched than that of witchgrass. Spikelets and seeds similar to those of witchgrass, but slightly longer, and narrowly ovoid in shape.

PLATE 130

Cenchrus pauciflorus 1. Inflorescence and leaf x1 1/3.
Agropyron repens 2. Inflorescence x2/3.
Agropyron smithii 3. Inflorescence and leaves. Separate leaf is dried and twisted longitudinally x2/3.

PLATE 131

Elymus canadensis 1. Inflorescence and leaf x2/3. 3. Spikelet cluster x1 1/3.
Lolium perenne 2. Inflorescence and leaf x2/3.

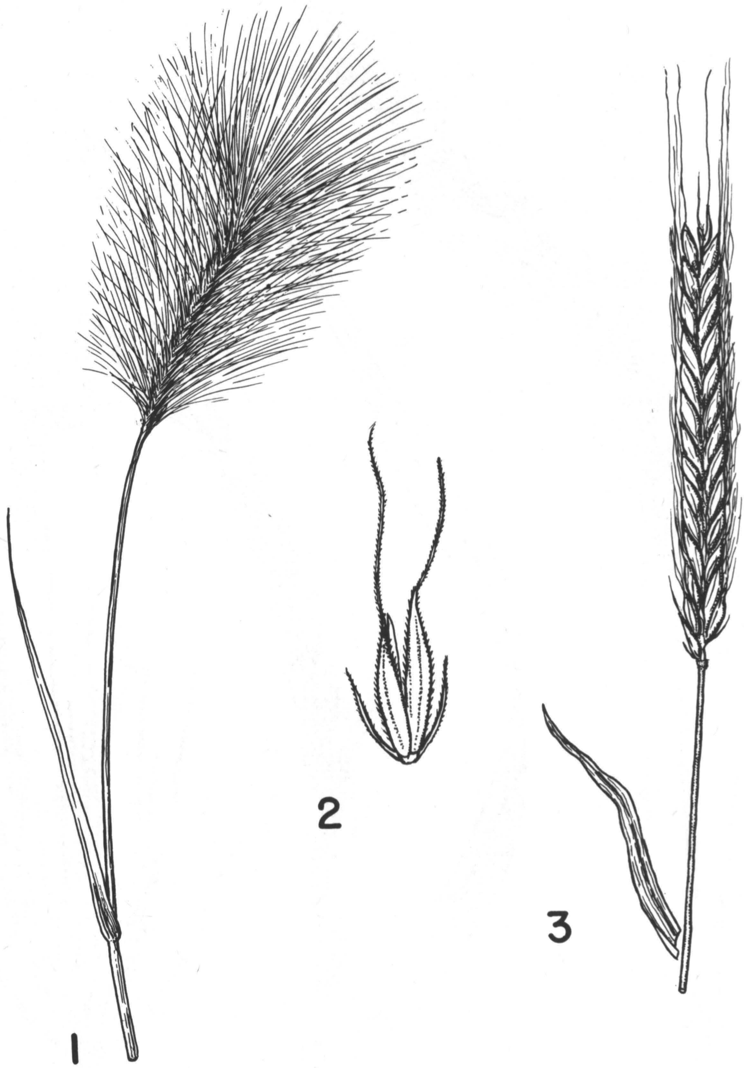


PLATE 132

Hordeum jubatum 1. Inflorescence x2/3.
Secale cereale 2. Spikelet x1 1/3. 3. Inflorescence x2/3.

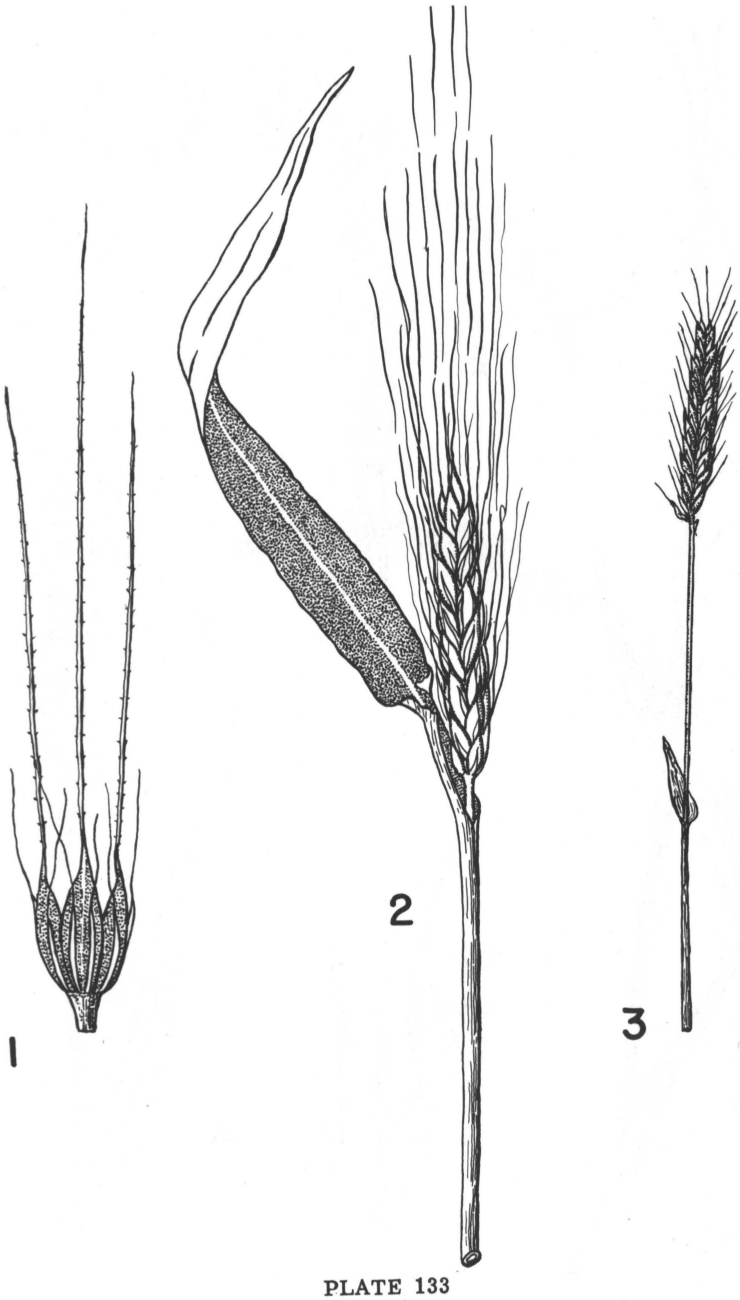


PLATE 133

Hordeum vulgare 1. Spikelet cluster x1 1/2. 2. Inflorescence x2/3.
Hordeum pusillum 3. Inflorescence x2/3.

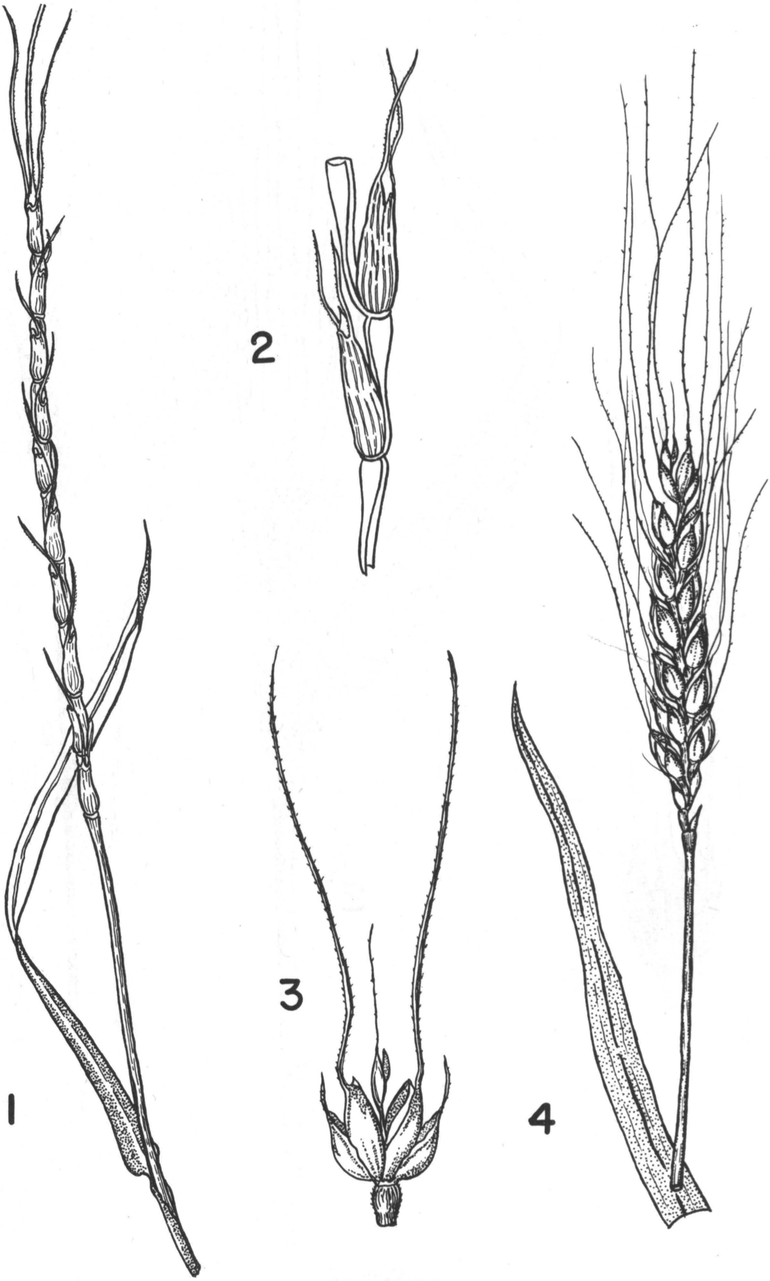


PLATE 134

Aegilops cylindrica 1. Inflorescence and leaf x2/3. 2. Adjoined spikelets and axis x2.
Triticum vulgare 3. Spikelet x1 1/3. 4. Inflorescence x2/3.

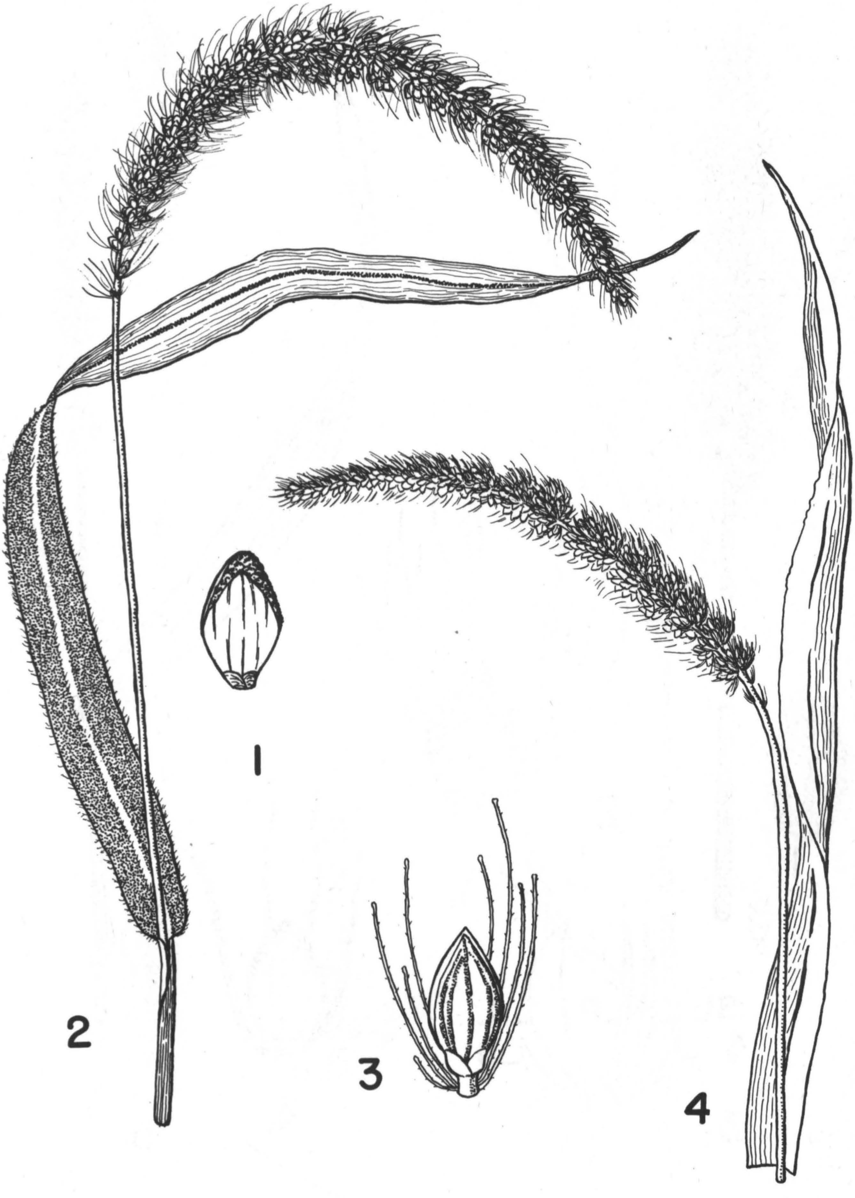


PLATE 135

Setaria faberii 1. Spikelet x4. 2. Inflorescence and leaf x2/3.
Setaria viridis 3. Spikelet x4. 4. Inflorescence and leaf x1.

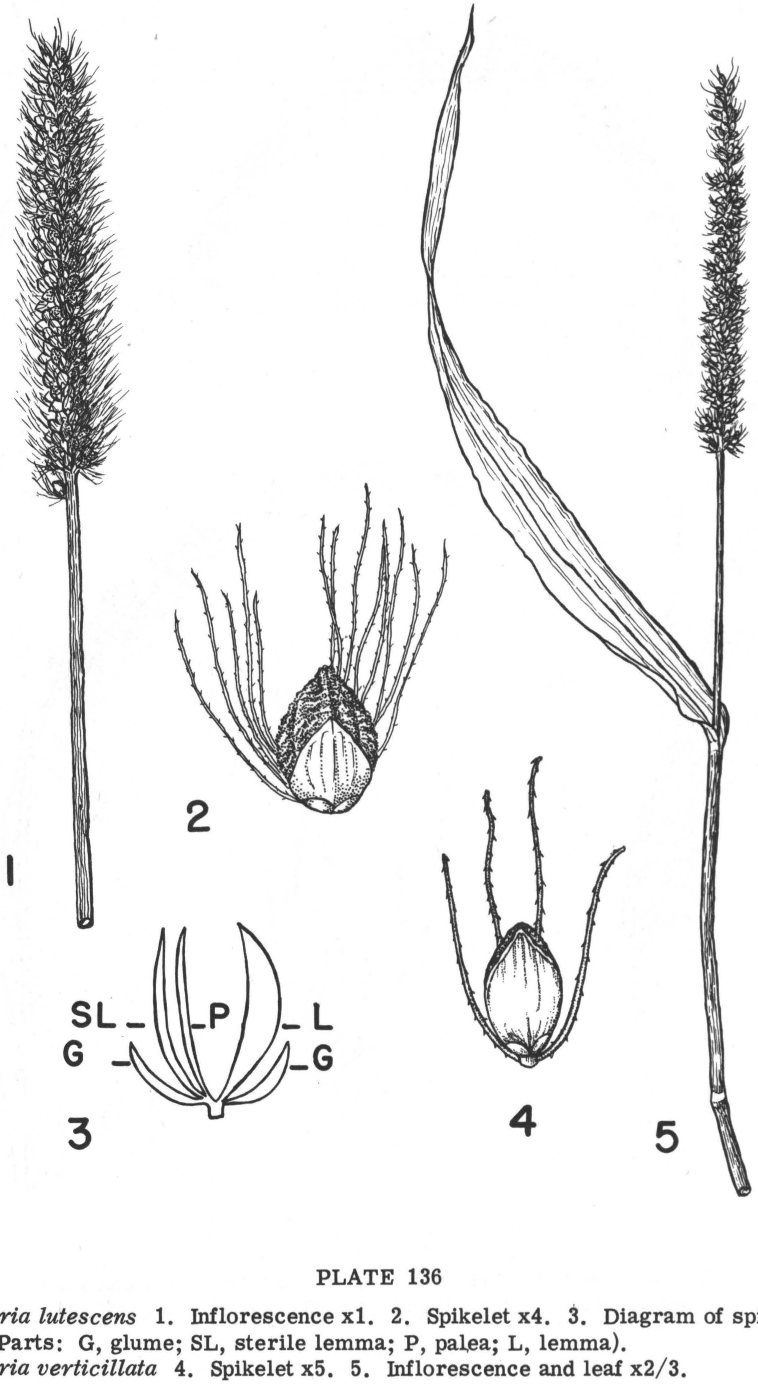


PLATE 136

Setaria lutescens 1. Inflorescence x1. 2. Spikelet x4. 3. Diagram of spikelet (Parts: G, glume; SL, sterile lemma; P, palea; L, lemma).
Setaria verticillata 4. Spikelet x5. 5. Inflorescence and leaf x2/3.

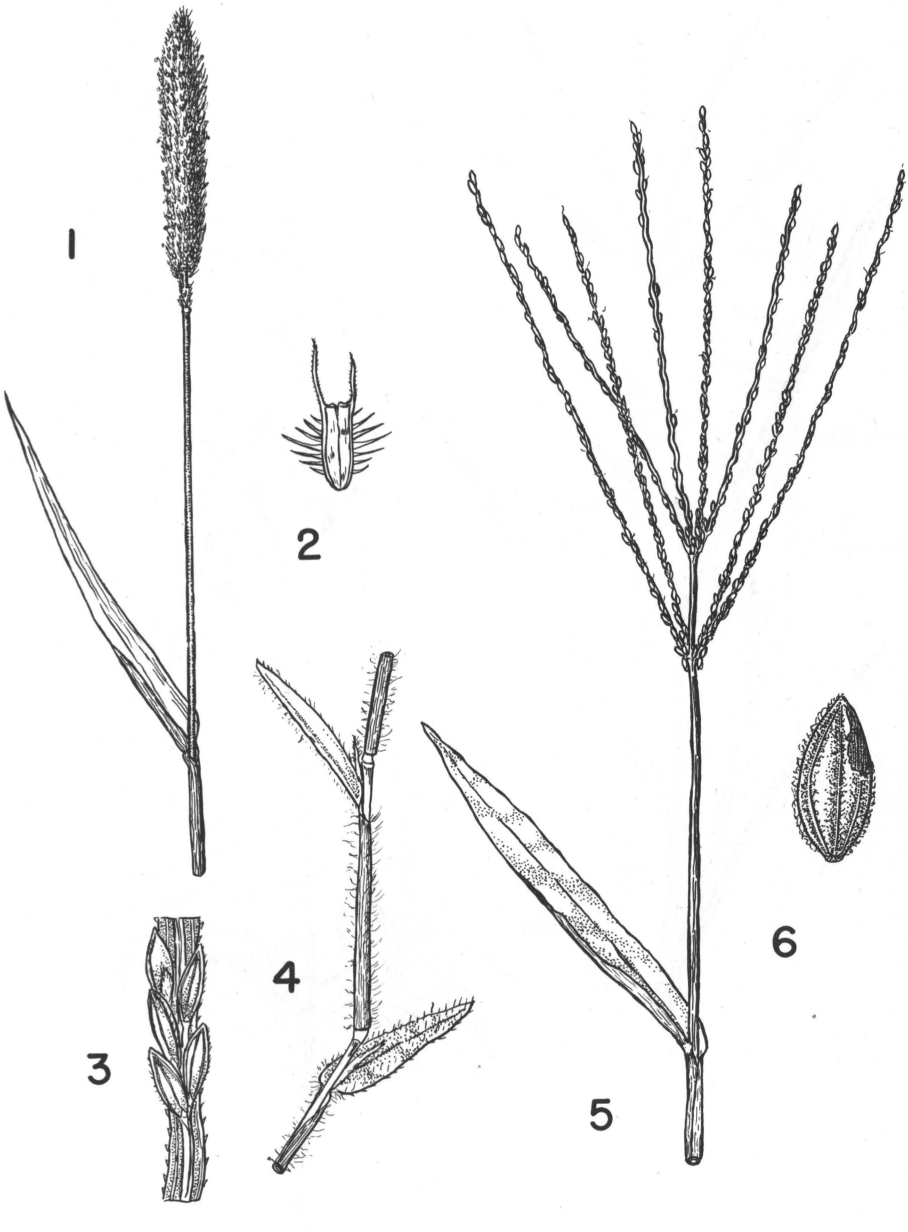


PLATE 137

Phleum pratense 1. Inflorescence and leaf x2/3. 2. Spikelet x3.
Digitaria sanguinalis 3. Spikelets on rachis x4. 4. Portion of leafy stem x2/3.
Digitaria ischaemum 5. Inflorescence and leaf x2/3. 6. Spikelet; glume torn at apex to reveal surface of fertile lemma.

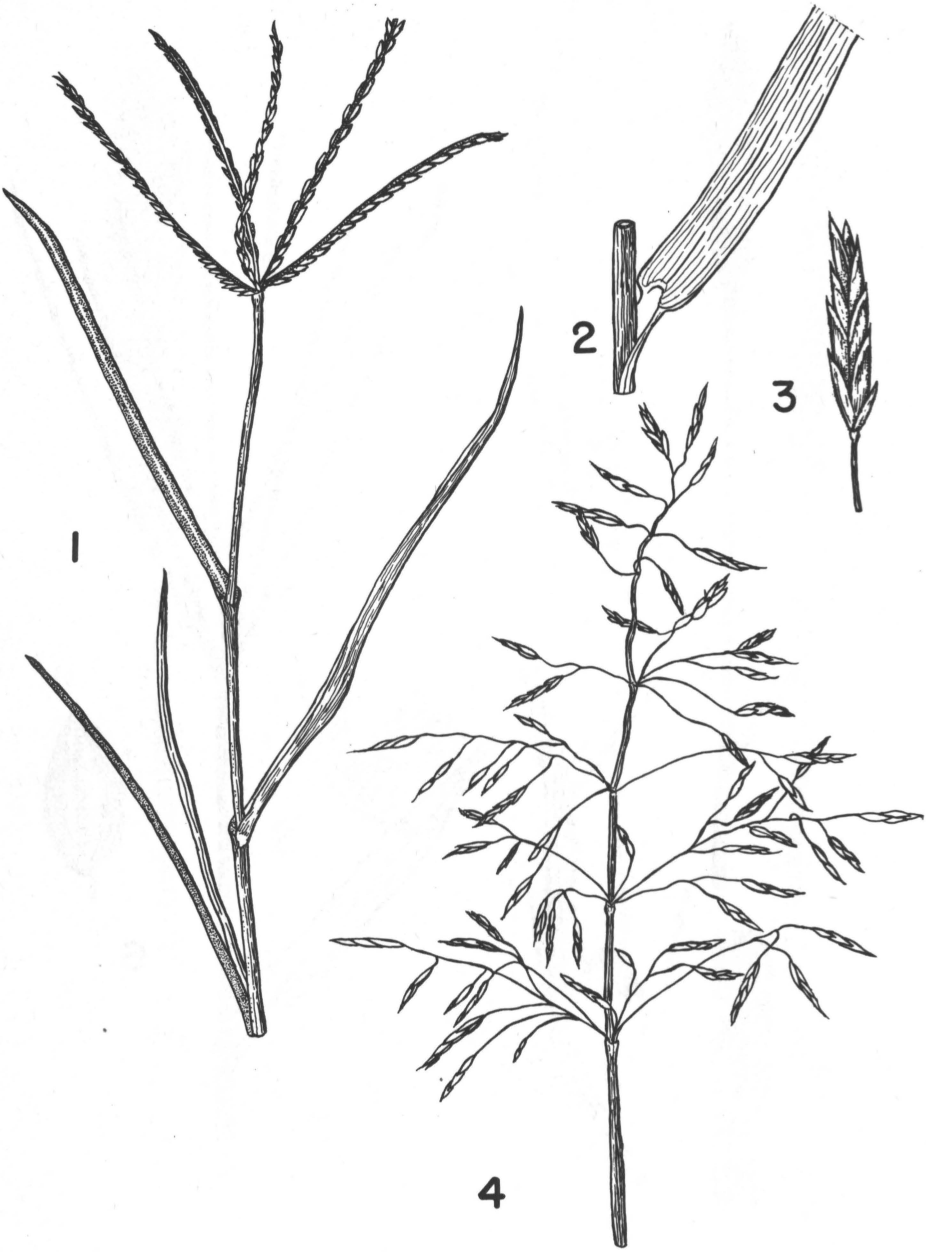


PLATE 138

Eleusine indica 1. Inflorescence and leaves x2/3.
Bromus inermis 2. Lower portion of leaf blade adjoining stem x1/2. 3. Spikelet x1 1/3. 4. Inflorescence x1/3.

PLATE 139
Cynodon dactylon Habit x2/3.

PLATE 140

Bromus japonicus 1. Leaves and stem x2/3. 2. Spikelet x3.
Bromus tectorum 3. Spikelet x3. 4. Inflorescence x2/3. 5. Stem and leaf x2/3.

PLATE 141

Bromus secalinus 1. Floret x2. 2. Inflorescence and leaf x2/3.
Festuca elatior 3. Spikelet x1 1/2. 4. Inflorescence branches and leaf x2/3.

PLATE 142

Avena fatua 1. Spikelet x2. 2. Floret x1 1/3.
Avena sativa 3. Inflorescence branches and leaf x2/3.
Poa pratensis 4. Inflorescence and leaf x2/3.

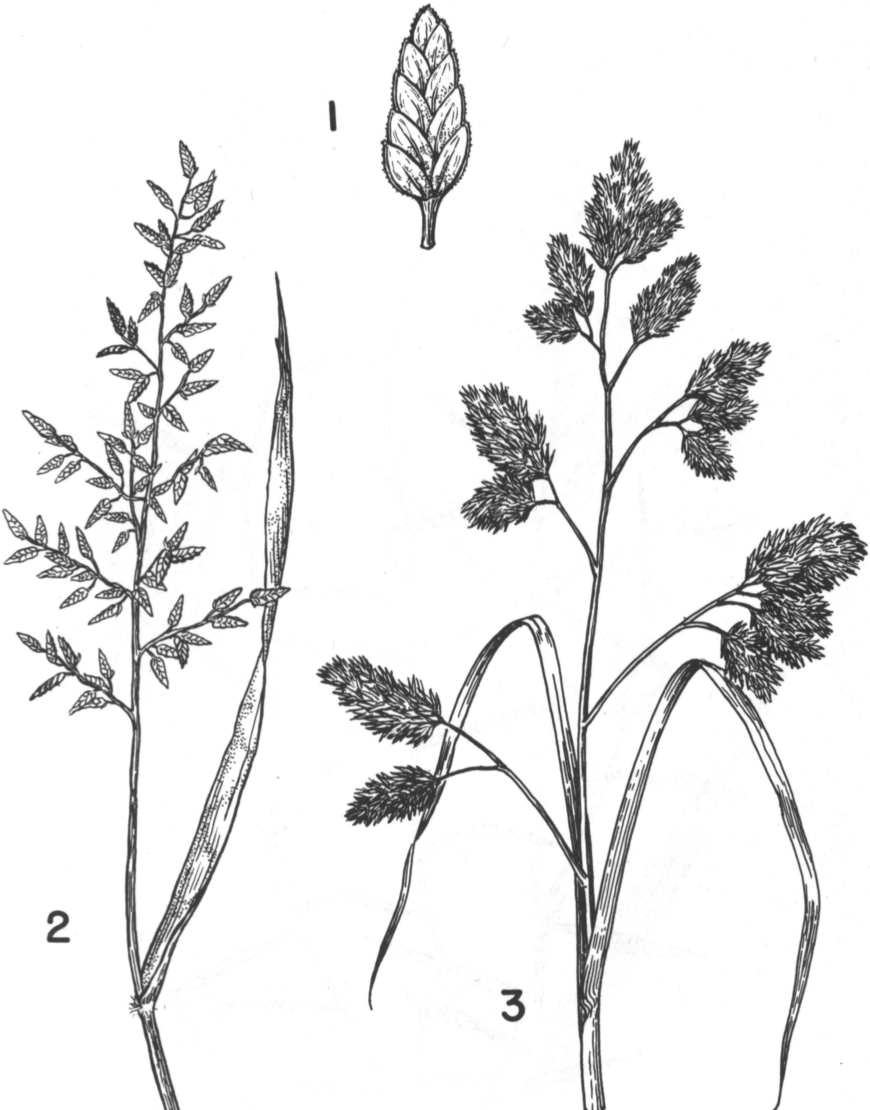


PLATE 143

Eragrostis cilianensis 1. Spikelet x3. 2. Inflorescence x2/3.
Dactylis glomerata 3. Inflorescence and leaves.

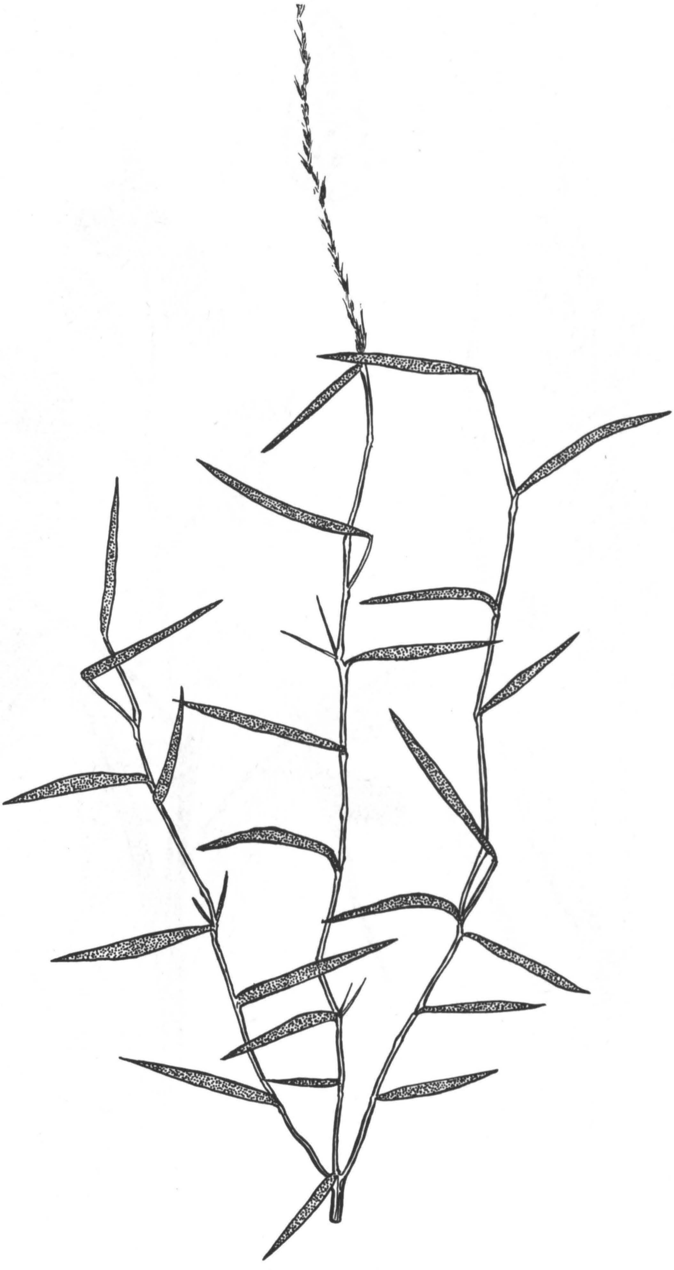


PLATE 144

Muhlenbergia schreberi Habit x2/3.

PLATE 145

Andropogon virginicus 1. Inflorescence x2/3.
Agrostis alba 2. Inflorescence and leaf x2/3.

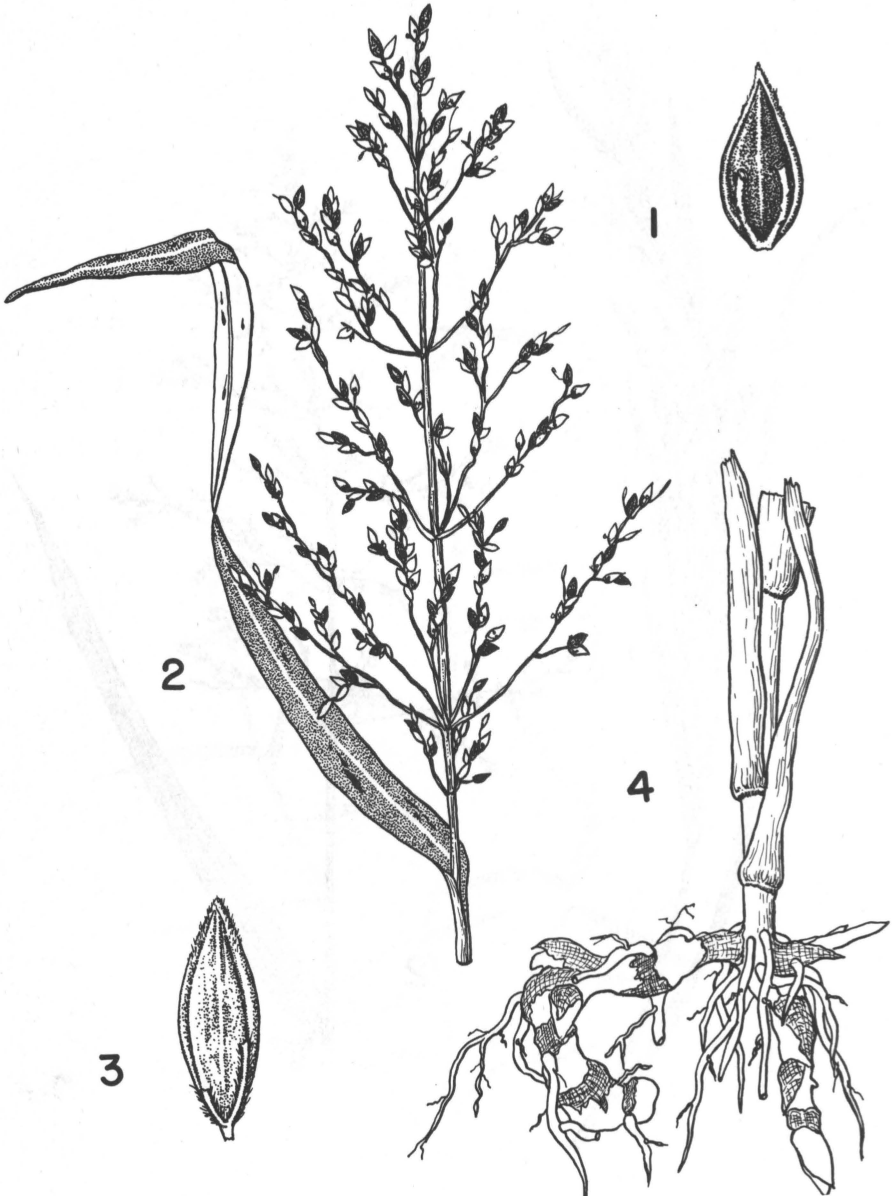


PLATE 146

Sorghum halapense 1. Spikelet x5. 2. Inflorescence and leaf x1/2. 4. Creeping rootstocks x1/2.
Sorghum sudanense 3. Spikelet x5.

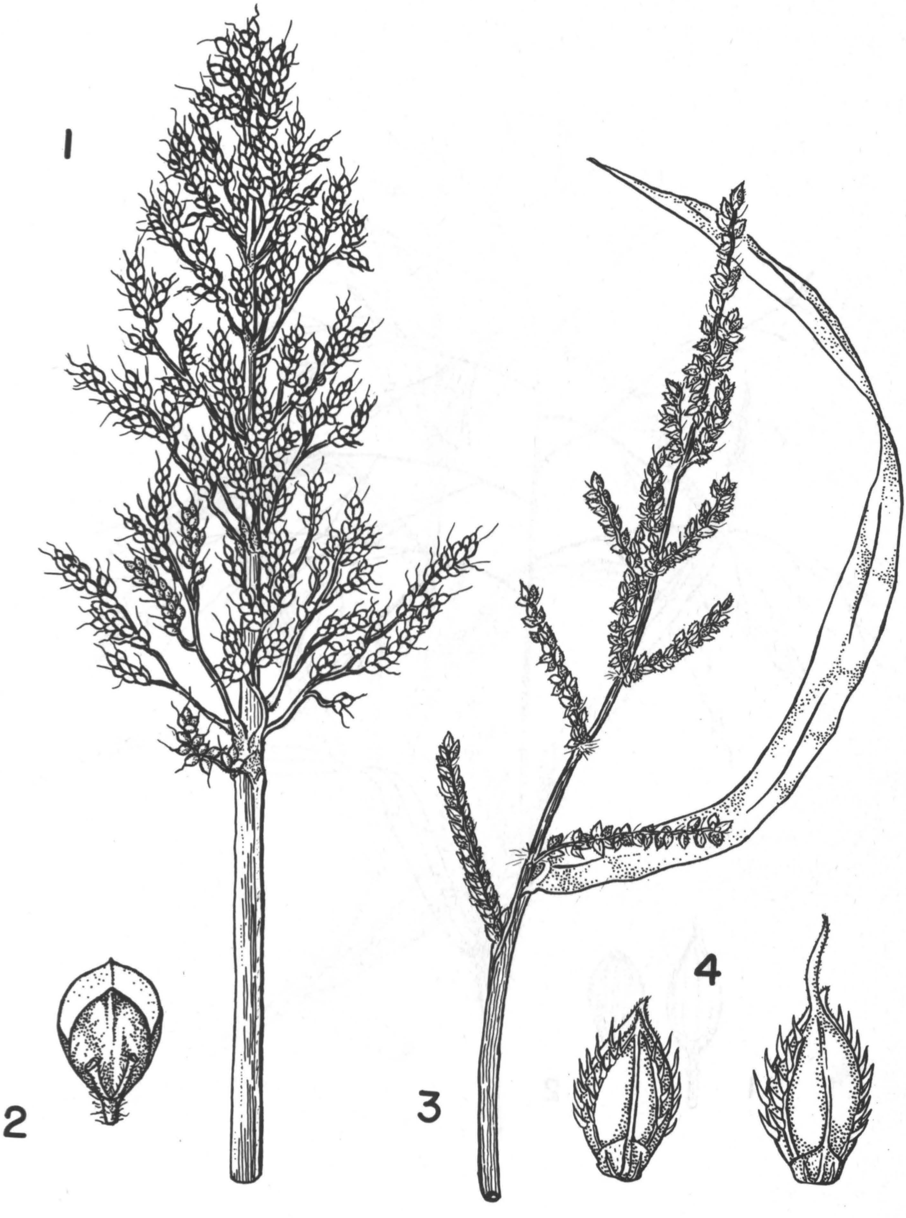


PLATE 147

Sorghum vulgare 1. Inflorescence x1/3. 2. Spikelet x2.
Echinochloa crusgalli 3. Inflorescence x2/3. 4. Spikelets x6.

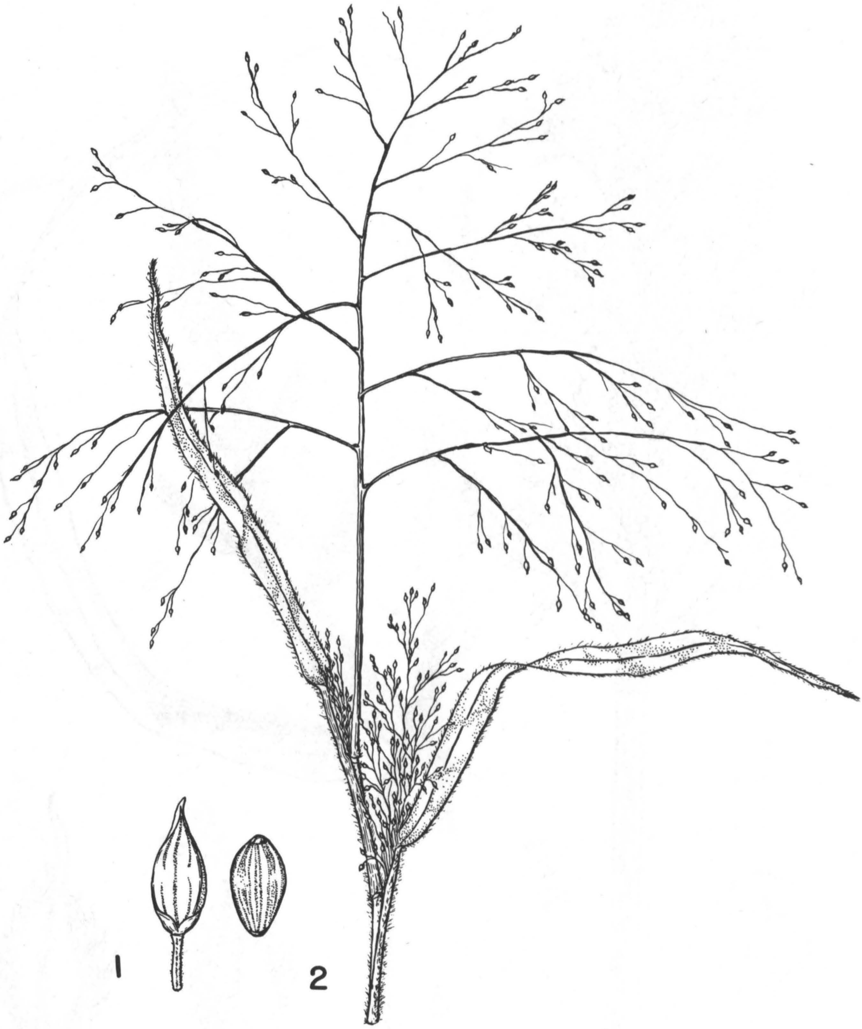


PLATE 148

Panicum capillare 1. Spikelet and floret x6. 2. Inflorescence x1/2.

PLATE 149
Panicum dichotomiflorum Habit x1/3.

PLATE 150

Aristida oligantha 1. Inflorescence x2/3.
Coreopsis tinctoria 2. Flower heads x2/3.

19. The Cyperaceae and Other Monocotyledonous Families

CYPERACEAE, SEDGE FAMILY

STEMS SOLID and 3-angled. Leaves similar to those of grasses, with a linear blade and basal sheath. Leaf sheath forming a closed tube about stem. Flowers without petals, variously arranged, often in spikes, enclosed by a single bract. Fruit a flattened or 3-angled achene with a thick, hard pericarp.

Sedges resemble grasses in general appearance and are often confused with them. They are most easily distinguished by their 3-rowed leaves and triangular stems as compared with the two rows of grass leaves and round or flattened stems. Most sedges have a stiffer, harsher feeling than grasses when handled.

In addition to the above, there are sedges which have round stems and almost no leaves (e.g. bulrushes, spikerushes). These kinds are marsh and aquatic plants and rarely occur on agricultural land.

Carex, Sedge, slough grass. Flowers in spikes, unisexual. Staminate and pistillate flowers separate and different in appearance. Pistillate flowers enclosed within a sac-like structure (perigynium), which is retained as a covering about the fruit. p239

There are more than 100 kinds of sedges in the North Central States, frequently abundant in low meadows and uncultivated fields, along ditches, fence rows, and roadsides. They are evident primarily in the spring and early summer.

Cyperus, *Cyperus esculentus*, Yellow nutgrass. Plants perennial with slender rhizomes which bear small, ovoid tubers. Inflorescence a panicle of brownish-yellow spikelets. Achenes brown, slenderly triangular, each enclosed by a single bract. Sporadic, most common Southeast, poorly drained or sandy soils. p239

JUNCACEAE, RUSH FAMILY

Juncus, Rushes. Plants similar to grasses and sedges in appearance. Stems rounded. Leaf sheaths closed. Blades narrow, often circular in cross section. Flowers in terminal, branched clusters, small, green. p239

Petals and sepals both present, but similar in appearance, green. Fruit a capsule with numerous, tiny seeds. Mostly wet areas, uncultivated land. One species is locally abundant along paths, roadsides, and in towns.

LILIACEAE, LILY FAMILY

Allium, Onion. Perennials, with an onion-like odor. Plants arising from a scaly bulb similar to an onion but considerably smaller. Leaves slender, narrow, rounded in cross section. Flowers usually replaced by a cluster of bulblets which arise at stem tip. Bulblets egg-shaped, similar to basal bulb but smaller.

p241 *Allium canadense*, Wild onion. Underground bulb with a fibrous "fishnet-like" covering. Leaves mostly basal. Bulblets broadly ovoid. Southern. Forage grasses, pastures, small grains; considered a noxious weed in many states. Wild onion is particularly undesirable in pastures since it imparts a taint to milk.

p240 *Allium vineale*, Wild garlic. Underground bulb with a smooth covering. Leaves arising from stem as well as near base. Bulblets slenderly obovoid. Range and attributes same as above.

PLATE 151

Cyperus esculentus 1. Inflorescence x2/3.
Carex frankii 2. Apex of plant (staminate spike broken off) x1/2.
Juncus tenuis 3. Capsule surrounded by perianth x6. 4. Habit x1 1/3.

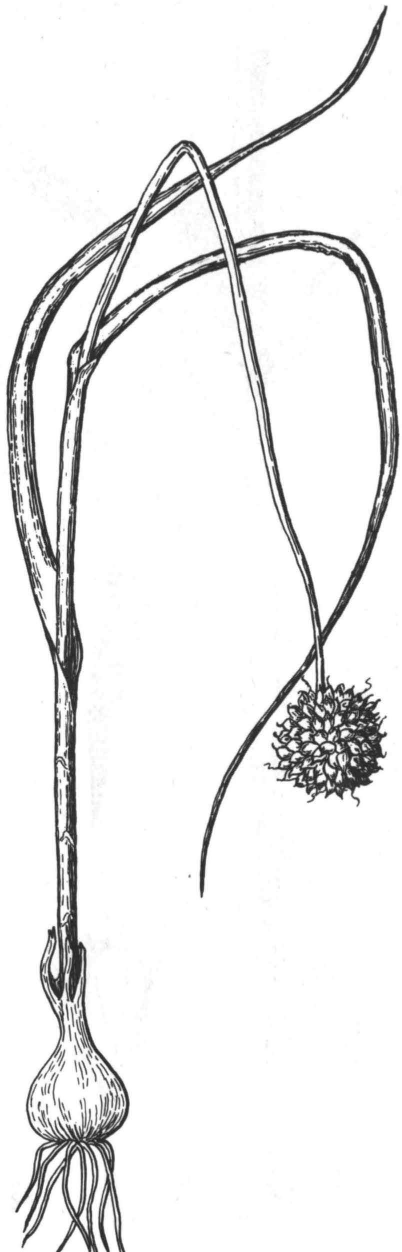


PLATE 152

Allium vineale Habit x2/3.

PLATE 153
Allium canadense Habit x2/3.

20. Synopsis of Plant Families Containing Numerous Weedy Species*

1. Fruit 1-seeded, commonly an achene or grain; leaves not trifoliate.
   2. Leaves grass-like, with a linear blade and a basal sheath surrounding the stem; inflorescences green; flowers not evident, hidden by surrounding bracts; petals and sepals absent; stamens usually three.
      3. Leaves in two rows on opposite sides of the rounded or flattened stem; flowers surrounded by 2 to several bracts; outline of embryo visible externally on grain.

         GRASS FAMILY *(Gramineae)*

      3. Leaves arising in three rows from triangular stems (certain sedges, not common as weeds, have rounded stems without evident leaves); flowers enclosed by a single bract and frequently a beaked, sac-like structure; outline of embryo not visible on seed.

         SEDGE FAMILY *(Cyperaceae)*

   2. Leaves usually not grass-like, sometimes with linear blades but without a basal sheath; flowers various, commonly with colored petals and usually not hidden by surrounding bracts; stamens generally more than three.
      4. Flowers small, in heads which simulate the appearance of a single flower; heads surrounded by 1 to several series of involucral bracts; seeds commonly with a cluster of bristles (pappus) at top.

         SUNFLOWER FAMILY *(Compositae)*

      4. Flowers and seeds not as above.
         5. A membranous sheath present, surrounding stem for a short distance above each node; seeds (achenes) 3-angled or flattened and pointed at tip.

            SMARTWEED FAMILY *(Polygonaceae)*

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*These diagnoses are of general usefulness for categorizing the principal kinds of weeds or for contrasting the family groups to which they belong. The generalizations presented do not, however, hold true for all species and genera occurring in the United States. The more technical keys, as found in botanical manuals, are necessary if such an objective is to be achieved.

5. Membranous sheath not present; seeds usually rounded in outline, sometimes horse-shoe shaped.
   6. Flowers with sharp-pointed bracts, inflorescence thus having a bristly appearance; seeds (of common weeds) shiny black.
      PIGWEED FAMILY *(Amaranthaceae)*

   6. Flowers not possessing sharp bracts, inflorescence not bristly; seeds usually dull black or gray.
      GOOSEFOOT FAMILY *(Chenopodiaceae)*

1. Fruit containing 2 to many seeds or if 1-seeded with trifoliate leaves.
   7. Flowers irregular.
      8. Plants with opposite, simple leaves; fruit splitting into 2 to 4 1-seeded segments (nutlets).
         MINT FAMILY *(Labiateae)*

      8. Plants with alternate, compound leaves; fruit a 1- to several-seeded pod.
         BEAN FAMILY *(Leguminosae)*

   7. Flowers regular or nearly so.
      9. Fruit indehiscent, splitting into 2 to 4 1-seeded segments.
         10. Leaves compound or dissected; flowers in umbels; fruit splitting into two segments.
             CARROT FAMILY *(Umbelliferae)*

         10. Leaves simple, serrate; flowers not in umbels; fruit usually splitting into four segments.
             11. Leaves opposite; fruits not bristly.
                 VERVAIN FAMILY *(Verbenaceae)*

             11. Leaves alternate; fruits commonly bristly.
                 BORAGE FAMILY *(Boraginaceae)*

      9. Fruit various, not as above.
         12. Leaves opposite or whorled.
             13. Fruit 3-chambered; leaves slightly toothed.
                 SPURGE FAMILY *(Euphorbiaceae)*
                 (in part, see 17)

             13. Fruit 1-chambered; leaves entire.
                 14. Flowers in umbels or umbel-like clusters; fruits exceeding 3 cm. in length; seeds flat with a long cluster of hairs; juice usually milky.
                     MILKWEED FAMILY *(Asclepiadaceae)*

14. Flowers not in umbels; fruits not more than 1.5 cm. in length; seeds neither flattened nor possessing a cluster of hairs; juice not milky.
PINK FAMILY *(Caryophyllaceae)*

12. Leaves alternate or in a basal cluster; fruit with more than one chamber.
15. Flowers with conspicuous, colored corollas of fused petals.
16. Plants vine-like, prostrate or twining (in species of the North Central States); fruit a capsule.
MORNING-GLORY FAMILY *(Convolvulaceae)*

16. Plants not vine-like; fruit a berry or capsule.
POTATO FAMILY *(Solanaceae)*

15. Flowers various, not as above.
17. Fruit a 3-chambered, 3-seeded capsule, juice commonly milky.
SPURGE FAMILY *(Euphorbiaceae)*
(in part, see 13)

17. Fruit not as above; plants not possessing milky juice.
18. Flowers greenish, in narrow spikes; leaves of common species all in a basal cluster.
PLANTAIN FAMILY *(Plantaginaceae)*

18. Flowers colored, not in spikes; stem leaves present.
19. Petals four; stamens six, free from one another; fruit 2-chambered.
MUSTARD FAMILY *(Cruciferae)*

19. Petals five; stamens fused by filaments into a tube surrounding style; fruit 3- to several-chambered.
MALLOW FAMILY *(Malvaceae)*

Identification of Weeds From Flowers and Leaves

21. Keys for Identifying Weeds

THE FOLLOWING KEY is adapted from one previously prepared by the author for publication in a North Central States regional bulletin "Weeds of the North Central States." With certain exceptions, the weed kinds treated are essentially the same as those discussed in this text.

This key employs a minimum of technical terms and botanical concepts. Agricultural workers and students who are "rusty" on botanical descriptions and the characteristics of weed families should find this outline useful for identifying unknown weedy plants in flower. So that it can serve this function, independent of the remainder of the text, it contains its own explanatory exposition and briefed-down glossary.

Those who can recognize plant families can possibly determine an unknown specimen more quickly by turning to the correct family in the text and comparing the plant with the descriptions and illustrations. The key should, however, be useful in verifying identifications.

HOW A KEY IS USED

A key is a device for identifying plants. It is an outline consisting of alternative statements about structure or appearance. From each pair of statements you choose the one that applies to the plant you are trying to identify. After you have made your first choice, you then choose from another pair subordinate to the first statement, and so on until you have finally identified the plant.

As an example, a short key to certain common cultivated legumes is given below. First look at the two headings labeled "1." If the plant to be identified has a rounded head of flowers, it will be found under the second "1." You will ignore everything under the first "1," since all the plants under that heading will have flowers in slender spikes. Next, you look at the two statements labeled "3" under the second "1." If the plant has white flowers, you choose the second "3." Subordinate to the second "3" is a pair of "4's." Assuming that the plant you are trying to identify is a trailing plant, rooting at the nodes, it "comes out" on the first "4" as white clover.

1. Flowers in slender spikes.
   2. Flowers yellow. YELLOW SWEET CLOVER
   2. Flowers white. WHITE SWEET CLOVER
1. Flowers in rounded heads.
   3. Flowers pink to red.
      RED CLOVER
   3. Flowers white or pinkish.
      4. Plants trailing, rooting at nodes; flowers white.
         WHITE CLOVER
      4. Plants ascending, not rooting at nodes; flowers white, becoming pink. ALSIKE CLOVER

Note that you always choose between one of two alternatives, and that the two alternatives bear the same number. Note also that a given number is used for only one pair of headings and is not repeated.

When you start to use the longer keys beginning on page 252, you will find that they follow the same principle. Often, however, one of a pair of statements will be quite widely separated from the other. For example, under the first "1" in Key 1, there are pairs of "2's," "3's," "4's," "5's," and "6's" before you come to the second "1." Sometimes the separation is much wider; you may have to turn a couple of pages before you come to the second of a statement pair. In all cases, choose between two statements bearing the same number and keep on choosing until the plant is identified.

USE OF TECHNICAL PLANT CHARACTERS IN A KEY

Individuals who easily recognize plants sometimes wonder why it is necessary to use technical details in a key, details which need not be observed in recognizing a plant. It should be borne in mind that *recognizing* a known plant and *identifying* an unknown one are two different processes.

Let us use a comparison. Most people who are interested in cars can usually differentiate even at a distance between popular makes regardless of model, year, or body type. This recognition is based upon a knowledge both of general form and of the detailed variations from model to model and from year to year, and perhaps involves a rapid, subconscious sorting of these details. But if one is to write down a few characteristics that will allow a person who has never paid any attention to cars to distinguish between two makes, one must turn to characteristics which remain fairly consistent regardless of year or model. For example, the insignias on the front of the hood would probably be constant enough to furnish a means of identification. And possibly certain details of the grille, the curvature of the fenders, or the nature of the hubcaps would be found consistent enough to be valuable.

A plant is usually recognized by a combination of superficial and frequently variable characteristics which if put into words would frequently require an involved description. On the other hand, plants must be identified by more or less consistent characteristics which serve as "signposts"; such characteristics may sometimes be small or technical in nature.

TECHNICAL TERMS

Arising out of the need for using technical characteristics is the necessity for technical terms. Most botanical keys contain a number of them. Obviously such words make it difficult for the person who has little familiarity with plants to use the key. But—returning to automobiles—one could scarcely discuss the ailments of his car intelligently with a mechanic if he did not know a few words such as carburetor, water pump, rings; even more or less everyday words such as steering wheel, dimmer switch, fender, and grille are names for parts of a car. In the same way, if plants are to be described with any precision, it is necessary to have words for their parts.

An attempt has been made in the following keys to hold technical terms to a minimum. In most cases, descriptive phrases are substituted for such terms. Frequently the appropriate or more exact technical term is placed in parentheses after the descriptive phrase—as a possible aid to those familiar with the terms. (Occasionally, the technical word is placed first and the descriptive phrase is put into parentheses after it.) The following words, however, are used without definition in the keys.

Duration of the Weed

Annual—lives one year. *Biennial*—lives two years. *Perennial*—lives several years. The annuals and biennials usually have only a taproot with small branches or, in the case of grasses, a fibrous root system. Perennials possess overwintering parts; for example, thickened crowns from which new shoots will arise, bulbs or tubers, or creeping underground stems (rootstocks) or roots.

Arrangement of the Leaves

Alternate—one leaf at each level on the stem. *Opposite*—two leaves opposite one another and paired. *Whorled*—three or more leaves at each level on the stem.

Nature of the Leaf

Simple—the leaf blade consists of a single piece and is not divided into separate leaflets. However, simple leaves are frequently toothed or lobed. Maple and elm leaves are simple leaves. *Compound*—the leaf blade is divided into several leaf-like parts which are called leaflets. The leaf of a hickory or locust is compound.

Leaf Shape

Ovate—egg-shaped, nearly elliptic but broadest at base. *Lanceolate*—lance-shaped, longer than ovate, and usually pointed at tip. *Linear*—long and narrow with nearly parallel sides. Grass leaves are linear.

Arrangement of the Flowers

If the flowers are in a definite cluster, usually at the top of the plant, they are said to be in an *inflorescense*. On the other hand, the flowers may be borne along the stem of the plant in the angles (leaf axils) between the foliage leaves and the stem. Such flowers are said to be axillary and, if in groups, comprise *axillary clusters*.

Flower Parts

The details of flower and fruit structure provide the best characteristics for identifying plants. But because of the technical nature of these parts they are little used in these keys. The expanded and usually colored parts of the flower are the *petals*. (However, many flowers possess no petals and are usually greenish or inconspicuous in appearance.) The *sepals* form the greenish hull around the flower when it is in bud; when the flower is open they lie outside and below the petals.

NATURE AND ARRANGEMENT OF THE KEYS

In the following keys precision of statement has been sacrificed to avoid the use of technical terms. As a result, some leads may appear ambiguous; in a few cases it may not be clear which alternative should be applied to the weed in hand. As far as possible, such difficulties have been anticipated and the plants concerned have been entered under both alternatives, that is, they may be keyed out in either "direction."

The keys to the weeds treated in this manual are as follows:

Usually flower color will readily indicate the key to be used. In doubtful cases, the following analysis in the form of a key will aid in determining the proper key to use; it also treats three plant kinds not included in the keys.

1. Plant a yellowish, twining vine without leaves, growing parasitically, usually on legumes or flax.
   DODDER *(Cuscuta pentagona)*[1] p. 140

1. Plants not as above.
  2. Plants producing neither flowers nor seeds; leaves (as described below) fernlike, or absent.
    3. Plant a fern; leaves (fronds) large, divided into numerous segments. BRACKEN *(Pteridium aquilinum)*

    3. Plant(s) with hollow, jointed stems and no leaves; stems of two kinds; one coming up early in the spring is whitish, unbranched, with a cone-like structure at tip; the second is green, with clusters of branches arising at each level.
       HORSETAIL *(Equisetum arvense)*

  2. Plants producing flowers and seeds; leaves present, various in nature.
    4. Plants not woody.
      5. Flowers with yellow, orange, cream-colored, or white petals or petal-like structures, occasionally greenish-white or faintly streaked with pink (the center of the flower, or flower head, is sometimes colored differently).
        6. Flowers yellow to orange, or cream-colored. KEY 1, page 252
        6. Flowers white. KEY 2, page 262
      5. Flowers other than yellow, orange, cream-colored, or white.
        7. Flowers red, pink, lavender, blue, or purple; petals usually present. KEY 3, page 271
        7. Flowers greenish to greenish-brown; petals usually absent. KEY 4, page 278
    4. Plants woody vines or shrubs. KEY 5, page 290

[1] Several kinds of dodder, similar in appearance to the above, may attack leguminous crops.

KEY 1. PLANTS WITH YELLOW, ORANGE, OR CREAM-COLORED FLOWERS

1. Plants (leaves or stems) spiny or prickly; plants usually possessing a milky juice.
   2. Plants consisting of a series of spiny pads or disks, without leaves; flowers more than 2 inches in diameter.
      PRICKLY PEAR *(Opuntia* spp.*)*

   2. Plants not as above, with leaves; flowers or flower heads less than 2 inches in diameter.
      3. Leaves and stems densely covered with rigid spines; juice not milky. BUFFALO BUR *(Solanum rostratum)* p. 157

      3. Leaves prickly along margins and sometimes lower midrib; stems not spiny; juice milky.
         4. Flowers (flower heads) less than 1/2 inch across, straw-yellow, very numerous in a diffuse flower cluster (panicle); leaves prickly on lower midrib as well as margins.
            PRICKLY LETTUCE *(Lactuca scariola)* p. 183

         4. Flower heads 1/2 to 1 1/2 inches across, bright yellow, usually 5 to 20 in number; leaves not prickly on lower midrib.
            5. Flower heads more than 1 inch in diameter (slightly smaller than those of a dandelion); plants perennial from creeping roots. PERENNIAL SOWTHISTLE *(Sonchus arvensis)* p. 184

            5. Flower heads 1/2 to 1 inch in diameter (about half the size of those of a dandelion); plants from an annual taproot.
               6. Leaf margin very prickly; base of the blade usually curled (auriculate) and clasping the stem; seeds (achenes) not cross-wrinkled.
                  SPINY SOWTHISTLE *(Sonchus asper)*

               6. Leaf margin soft-prickly; leaf base tapering, not clasping the stem, or some of upper leaves slightly clasping; achenes irregularly ridged and cross-wrinkled.
                  COMMON SOWTHISTLE *(Sonchus oleraceus)* p. 185

1. Plants (leaves or stems) not spiny; in a few cases the fruit is spiny or prickly.
   7. Plants without a leafy stem or prostrate stolons; leaves all in a cluster (rosette) at ground level; flower heads solitary on hollow, leafless stalks.
      8. Seeds (achenes) red-brown to reddish-purple; leaves usually dissected nearly to the midrib with narrow, frequently downwardly curved (runcinate) lobes; inner bracts around head (phyllaries)

with horn-like appendages.[2]
RED-SEEDED DANDELION *(Taraxacum erythrospermum)*

8. Achenes olive-drab to dull brown; leaves extremely variable, deeply dissected or only irregularly toothed; phyllaries not appendaged.
DANDELION *(Taraxacum officinale)* p. 186

7. Plants with a leaf-bearing stem, erect or prostrate; flowers or flower heads various, not arising directly from a basal rosette (stem leaves are much reduced in Hawkweeds, *Hieracium* spp., which possess flower heads clustered at stem tip; frequently stolons are evident).
9. Plants prostrate, trailing, or spreading.
10. Leaves compound.
11. Leaflets 8 to 16; fruit a spiny bur.
PUNCTURE VINE *(Tribulus terrestris)* p. 113

11. Leaflets 3; fruit a 1-seeded pod.
BLACK MEDIC *(Medicago lupulina)* p. 97

10. Leaves simple.
12. Plant very fleshy with small, entire leaves; flowers less than 1/2 inch across; fruit a small capsule.
PURSLANE *(Portulaca oleracea)* p. 70

12. Plant not fleshy, with large, irregularly toothed leaves; flowers large, more than 2 inches long; fruit gourd-like.
WILD GOURD *(Cucurbita foetidissima)*

9. Plants erect or ascending (a few kinds may root at lower nodes or possess trailing stolons as well as erect stems).
13. Leaves compound, divided into distinct leaflets, or some or all of leaves dissected into numerous fine segments and usually appearing fern-like.
14. Leaves compound, divided into distinct leaflets which are ordinarily more than 1/4 inch wide.
15. Leaves opposite; flowers in head (each appearing like a single flower); fruits 1-seeded (achenes), with 2 barbed, sharp projections (awns) at top.
BEGGAR'S-TICKS *(Bidens frondosa)*

15. Leaves alternate; flowers not borne in heads; fruits various.
16. Leaflets 3, entire except for a notch at apex (obcordate); each flower producing a single, many-seeded fruit (capsule). YELLOW SORREL *(Oxalis europaea)* p. 112

[2] Our two kinds of dandelions are difficult for anyone except a specialist to distinguish.

16. Leaflets various in number, toothed or lobed; fruits not capsular, frequently several produced by each flower.
  17. Leaves pinnately compound (leaflets arising from an elongated midrib or axis); flowers umbellate (numerous flower stalks arising from same point); each flower producing 1 fruit, which, at maturity, splits into 2 flat, 1-seeded segments (mericarps).
      WILD PARSNIP *(Pastinaca sativa)* p. 129

  17. Leaves palmately compound (leaflets arising finger-like from apex of leaf stalk); flowers not umbellate; each flower producing several 1-seeded fruits (achenes).
    18. Leaflets lobed or dissected, frequently running together at base, their exact number difficult to determine; stipules (appendages where leaf stalk joins stem) not evident.
        TALL BUTTERCUP *(Ranunculus acris)*

    18. Leaflets toothed, clearly distinguishable and easy to count; stipules present.
      19. Under surface of leaves silvery-hairy.
          SILVERY CINQUEFOIL *(Potentilla argentea)*

      19. Under surface of leaves greenish.
        20. Leaflets 5 to 9; petals large, exceeding other flower parts.
            SULPHUR CINQUEFOIL *(Potentilla recta)* p. 92

        20. Leaflets 3; petals small and inconspicuous, scarcely exceeding sepals (greenish hulls at base of flower).
            ROUGH CINQUEFOIL *(Potentilla norvegica)* p. 92

14. Leaves not divided into distinct leaflets; some or all of leaves dissected into numerous fine segments which are usually less than 1/4 inch wide, the whole leaf presenting a somewhat fern-like appearance.
  21. Leaves all alternate.
    22. Flowers with 4 distinct petals set at right angles to one another; fruit resembling a slender pod (silique), containing several yellowish seeds; plants not scented.
      23. Mature pods more than 2 inches long; main segments of basal (rosette) leaves usually not dissected into secondary segments (1-pinnatifid).
          TUMBLING MUSTARD *(Sisymbrium altissimum)* p. 82

      23. Mature pods less than 1 inch long; main segments of basal leaves usually dissected into secondary segments (2-pinnatifid).
          TANSY MUSTARD *(Descurainia pinnata)* p. 78

22. Flowers (flower heads) not possessing marginal petal-like structures, button- or bell-shaped; fruits one-seeded, not pod-like, clustered together in the heads; plants usually strongly scented.
  24. Flower heads yellow or orange, erect, 1/4 inch or more wide.
    25. Plants perennial; stems usually a foot or more in height; main leaf segments crowded, pinnatifid; flower heads orange, in a dense, flat-topped cluster.
TANSY *(Tanacetum vulgare)*

    25. Plants annual; stems less than a foot high; leaf segments slender, entire, distant; flower heads yellowish, not densely clustered.
PINEAPPLE WEED *(Matricaria matricarioides)*

  24. Flower heads yellowish-white, gray-yellow, or greenish, frequently bent over (nodding), distinctly less than 1/4 inch wide.
    26. Plants greenish, relatively smooth; strong-scented annuals arising from a taproot.
WORMWOOD *(Artemisia annua)*

    26. Plants white-silky or woolly, scarcely scented; perennials from spreading rhizomes.
MUGWORT *(Artemisia absinthium)*

21. Leaves all opposite, or only the lower opposite.
  27. Flower heads with a dark center and large, petal-like marginal (ray) flowers; lower leaves with thread-like (filiform) segments, the upper mostly undivided.
COREOPSIS *(Coreopsis tinctoria)* p. 236

  27. Flower heads without a dark center; ray flowers, if present, small and inconspicuous; leaves fern-like.
    28. Leaves all opposite; flower heads single or in small groups at tips of branches, with small ray flowers; seeds columnar with points at the tip which readily adhere to clothing.
SPANISH NEEDLES *(Bidens bipinnata)* p. 199

    28. Leaves alternate above, opposite below; conspicuous flower heads (not setting seeds) in slender spikes, without ray flowers; seeds short and broad, not adhering to clothing, produced in axils of upper leaves.
      29. Plants annual, very common; leaves smooth above, usually much divided, the main segments being dissected into secondary divisions (2-pinnatifid); fruits with a distinct crown of points at tip. COMMON RAGWEED *(Ambrosia elatior)* p. 176

      29. Plants perennial from creeping roots (first-year plants appear annual), very similar in appearance to common ragweed

but much less common; leaves rough above, less divided than in above species, the main segments frequently lobed but not again divided (1-pinnatifid); fruits with a very short crown of points or nearly smooth at tip.

PERENNIAL RAGWEED *(Ambrosia psilostachya)* p. 177

13. Leaves neither compound nor dissected into fine segments, if lobed or divided (pinnatifid) the blades not fern-like, or the segments relatively broad or coarse.
  30. Petals 4, placed at right angles to one another (flowers cross-like); fruit pod-like (a silique), elongate or ball-shaped, several-seeded (one exception), frequently with a beak at the tip.
    31. Pods upwardly appressed against stem.
      32. Flowers less than 1/4 inch across; beak of pod indistinct, less than 1/16 inch long; upper leaves with 3 narrow lobes.

HEDGE MUSTARD *(Sisymbrium officinale)* p. 83

      32. Flowers more than 1/4 inch across; beak of pod evident, about 1/8 inch long; upper leaves irregularly toothed.

BLACK MUSTARD *(Brassica nigra)* p. 77

    31. Pods spreading, ascending, or nearly erect, but not appressed against stem.
      33. Pods spherical (globose) to egg-shaped (ovoid); leaves clasping the stem by basal lobes.
        34. Plants perennial from creeping roots; pods splitting open at maturity (dehiscent), with numerous tiny seeds.

AUSTRIAN FIELD CRESS *(Rorippa austriaca)*

        34. Plants annual; pods not splitting open at maturity (indehiscent), with 1 large seed, or sometimes 2.

BALL MUSTARD *(Neslia paniculata)* p. 80

      33. Pods oblong to linear; leaves clasping or not clasping.
        35. Plants smooth or with a few scattered hairs (glabrate).
          36. Leaves with a pair of basal lobes clasping about the stem, otherwise entire (neither toothed or lobed); seed pods frequently 3 inches long, and often nearly vertical in position.

HARE'S EAR MUSTARD *(Conringia orientalis)* p. 79

          36. Leaves not clasping the stem, toothed or lobed; seed pods various, if vertical in position shorter than above.
            37. Basal leaves with a broadly rounded terminal lobe; foliage shiny green; seed pods usually not exceeding 1 inch in length; seeds somewhat flattened.

YELLOW ROCKET *(Barbarea vulgaris)* p. 75

37. Basal leaves with pointed lobes; foliage often somewhat whitish-green; seed pods usually exceeding 1 inch in length; seeds spheroid. INDIAN MUSTARD *(Brassica juncea)* p. 77

35. Plants conspicuously bristly-hairy.

38. Fruit jointed at maturity breaking crosswise into segments which contain 1 or 2 seeds; basal leaves usually divided to the midrib into separate segments.
WILD RADISH *(Raphanus raphanistrum)* p. 78

38. Fruit splitting longitudinally to release seeds at maturity; basal leaves irregularly toothed or pinnatifid, but not divided to midrib. WILD MUSTARD *(Brassica kaber)* p. 76

30. Petals not 4 in number; fruit various, not a silique.

39. Leaves alternate, occasionally the uppermost or the lower opposite, or rarely nearly all in basal clusters (rosettes).

40. Fruit a 3-lobed, 3-seeded capsule which hangs downward at maturity; leaves narrowly strap-shaped, crowded on the mostly unbranched stem; juice milky.

41. Leaves about 1/8 inch wide.
CYPRESS SPURGE *(Euphorbia cyparissias)* p. 106

41. Leaves 1/4 to 3/4 inch wide.
LEAFY SPURGE *(Euphorbia esula)* p. 105

40. Fruit not a 3-lobed, 3-seeded capsule; plants otherwise not with the above combination of characters.

42. Flowers without petals or petal-like structures; flowers (flower heads) appearing as erect or drooping yellow discs, or the inflorescence a cluster of short, flat spikes.

43. Leaves grass-like; stems 3-angled; inflorescence a cluster of short, flat spikes.
YELLOW NUTGRASS *(Cyperus esculentus)* p. 239

43. Leaves not grass-like; stems rounded; inflorescence of disc-like flower heads.

44. Flowers (flower heads) on stalks in a branched flower cluster; stem leaves strap-shaped, not toothed; seeds with a cluster of hairs (pappus) at tip.

45. Stem unbranched below inflorescence, frequently 3 to 6 feet tall; leaves crowded, strap-shaped.
HORSEWEED *(Erigeron canadensis)* p. 200

45. Stem branched, low, usually not much exceeding 1 foot; leaves narrowly linear.
DWARF FLEABANE *(Erigeron divaricatus)*

44. Flower heads not stalked (sessile), arising directly from an unbranched axis; leaves usually with a pair of teeth at base; seeds not possessing a pappus.
LANCE-LEAVED RAGWEED *(Ambrosia bidentata)* p. 177

42. Flowers with petals or petal-like structures.
46. Flowers closely associated in heads, each head simulating a single flower; flowers in the head all similar, strap-shaped, and each appearing like a single petal (ray flowers), or of two kinds: small tubular flowers which are crowded together in a central disc, and marginal (ray) flowers which look like petals; each head setting several to many seeds (achenes), which frequently bear a cluster of hairs or bristles (pappus) at the apex.
47. Heads with no central disc; flowers all of the strap-shaped ray-flower type, petal-like; fresh plants frequently with a milky juice.
48. Leaves entire, grass-like; heads large, 1 1/2 to 2 1/2 inches across. YELLOW GOATSBEARD *(Tragopogon dubius)* p. 186

48. Leaves not grass-like, some or all of them usually toothed or lobed; heads usually less than 1 inch across.
49. Leaves mostly in basal rosettes; erect stems bearing only 1 to 3 reduced blades; prostrate leaf-bearing stolons often evident.
50. Flower heads orange.
ORANGE HAWKWEED *(Hieracium aurantiacum)* p. 182

50. Flower heads yellow.
HAWKWEED *(Hieracium pratense)*

49. Leaves of mature plants not mostly in rosettes, those on stems numerous; stolons not present.
51. Leaves soft-prickly, the teeth or lobes drawn out into bristles, or leaves soft-prickly on lower midvein.
52. Midvein on under surface of leaves prickly with a row of bristles; most of stem leaves twisted sidewise to that blade is in a vertical position (one edge above the other); heads less than 1/2 inch in diameter.
PRICKLY LETTUCE *(Lactuca scariola)* p. 183

52. Midvein not prickly; leaves horizontal in position; heads more than 1/2 inch in diameter.
COMMON SOWTHISTLE *(Sonchus oleraceus)* p. 185

51. Leaves not prickly-margined.
53. Branches of flower clusters (inflorescences), arched or recurving, bearing the crowded flowering heads primarily on one side in a curved wand; leaves mostly

stalked, not clasping the stem.
GOLDENROD *(Solidago*[3] *spp.)* p. 204

53. Branches of inflorescence erect or ascending, bearing upright heads at the tip; stem leaves mostly without stalks (sessile), with lower portion of the blade clasping.
  54. Plants tall (3 to 8 feet) with densely leafy stems; heads very numerous, less than 1/2 inch wide; seeds (achenes) black, beaked. WILD LETTUCE *(Lactuca canadensis)*

  54. Plants low, usually about 1 foot tall, frequently with several branches from base; heads 3/8 to 3/4 inch in diameter; seeds (achenes) brown, not beaked.
  HAWKSBEARD *(Crepis capillaris)*

47. Heads with a central disc of tubular flowers and marginal, petal-like ray flowers; plants not possessing a milky juice.
  55. Central disc of head (tubular flowers) dark in color.
    56. Seeds (achenes) black, brick-shaped, 1/8 inch or less in length; leaves oblong to strap-shaped, less than one inch in width.
    BLACK-EYED SUSAN *(Rudbeckia hirta)*

    56. Seeds white, gray or brown, larger than above; leaves usually broadly ovate to lanceolate and 1 inch or more in width.
      57. Leaves rough (scabrous); seeds (achenes) dull white to gray, hairy at tip, 1/4 to 3/8 inch long (this species apparently sometimes crosses with following one).
      SUNFLOWER *(Helianthus annuus)* p. 204

      57. Leaves hairy but not markedly rough; seeds pale brown, hairy all over, less than 1/4 inch long.
      SAND SUNFLOWER *(Helianthus petiolaris)*

  55. Entire head yellow.
    58. Seeds bearing at apex a cluster (pappus) of numerous fine bristles. (Note: In immature flowering heads the pappus is hidden by the flowers and the head must be split to find it; however, after the head begins to ripen, it is easily visible externally.)
      59. Stem leaves pinnatifid (lobed along an elongated midrib); flower heads more than 1/2 inch across.
      GOLDEN RAGWORT *(Senecio aureus)*

      59. Stem leaves toothed or entire; flower heads not exceeding 1/2 inch. GOLDENROD[3] *(Solidago spp.)* p. 204

[3] Several kinds of goldenrods are common in the fall of the year.

58. Seeds not bearing a pappus of numerous fine bristles; pappus absent, of scales, or of a few (5 to 10) somewhat flattened, stiff bristles.
  60. Stem leaves narrowly linear or thread-like.
    61. Heads 1/2 to 3/4 inch wide; marginal ray flowers lobed at tip.
BITTERWEED *(Helenium tenuifolium)* p. 203

    61. Heads less than 1/2 inch wide; ray flowers not lobed.
BROOMWEED *(Amphiachyris dracunculoides)*

  60. Leaves broader than above, not linear.
    62. Stems winged by attached basal portions of leaf blades (leaves decurrent); ray flowers 3-toothed or lobed at tip.
COMMON SNEEZEWEED *(Helenium autumnale)* p. 202

    62. Stems not winged; ray flowers not toothed.
      63. Plants finely hairy, often somewhat rough; perennial from rhizomes and tubers; heads not sticky or gummy.
        64. Central disc (not including petal-like rays) of heads usually 3/8 to 3/4 inch broad; lowermost leaves opposite; rhizomes bearing enlarged tubers.
JERUSALEM ARTICHOKE *(Helianthus tuberosus)*

        64. Central disc of heads 3/4 to 1 1/2 inches broad; leaves all alternate; rhizomes not tuber-bearing.
MAXIMILIAN'S SUNFLOWER *(Helianthus maximiliani)*

      63. Plants smooth (glabrous), without rhizomes or tubers; heads gummy. GUMWEED *(Grindelia squarrosa)* p. 201

46. Flowers separate, not associated in heads; fruits and seeds various, not possessing a pappus.
  65. Leaves velvety-hairy or densely woolly.
    66. Fruit a berry enclosed in an angular, papery husk; plant perennial from creeping rootstocks.
GROUND CHERRY *(Physalis heterophylla)*[4] p. 155

    66. Fruit a dry capsule which splits open at maturity, not enclosed within a husk; plants annual or biennial, not possessing creeping rootstocks.
      67. Plants gray-woolly; flowers in a dense spike; leaves not heart-shaped at base.
MULLEIN *(Verbascum thapsus)* p. 160

      67. Plants velvety; flowers not in a spike; leaves heart-shaped at base. BUTTERPRINT *(Abutilon theophrasti)* p. 122

[4] Several species of *Physalis* are weedy. Not all of them are downy-hairy or perennial, but all have the characteristic berry enclosed in the husk-like calyx.

65. Leaves smooth (glabrous) or hairy, but neither velvety nor densely woolly.
  68. Basal leaves palmately divided into 3 to 7 main segments which are further subdivided.
    69. Flowers pale yellow, purplish in center; each flower produces a single large several-seeded fruit (capsule), partially surrounded by a bladdery hull; plant annual.
    SHOOFLY *(Hibiscus trionum)* p. 123

    69. Flowers bright yellow throughout; each flower produces numerous small seed-like fruits; plants perennial.
    TALL BUTTERCUP *(Ranunculus acris)*

  68. Basal leaves not palmately dissected.
    70. Basal (rosette) leaves as broad as long, heart-shaped.
    SMALL-FLOWERED BUTTERCUP *(Ranunculus abortivus)* p. 94

    70. Basal leaves longer than broad, not heart-shaped.
      71. Leaves entire, strap-shaped, not hairy; flowers not symmetrical, the petals of different sizes (irregular).
      YELLOW TOADFLAX *(Linaria vulgaris)* p. 161

      71. Leaves toothed or shallowly lobed, hairy; flowers with petals of same size (regular).
        72. Leaves stalked (petioled); flowers scattered; fruit splitting into 5 seeds.
        PRICKLY SIDA *(Sida spinosa)* p. 125

        72. Leaves not stalked (sessile); flowers in a terminal spike; fruit with many seeds.
        EVENING PRIMROSE *(Oenothera biennis)* p. 126

39. Leaves all opposite.
  73. All leaves, or only the lower, lobed or cleft into segments.
    74. Flowers (flower heads) in narrow spikes, without petals or petal-like structures; leaves mostly with 3 to 5 big lobes (palmately lobed).
    GIANT RAGWEED *(Ambrosia trifida)* p. 177

    74. Flower heads separate at stem tips, with large petal-like ray flowers; lower leaves with 3 to 7 lobes (pinnately lobed), upper blades often unlobed.
    TALL CONE FLOWER *(Rudbeckia laciniata)*

  73. Leaves toothed or entire.
    75. Bases of upper, paired leaves joined together and forming a cup about stem at nodes.
    CUP PLANT *(Silphium perfoliatum)*

    75. Bases of leaves not joined together.
    ST. JOHN'S WORT *(Hypericum perforatum)*

KEY 2. PLANTS WITH WHITE FLOWERS

1. Leaves opposite or whorled.
   2. Leaves whorled (several at each level on stem).
      3. Plants forming prostrate mats; flowers in small axillary clusters; seeds very small, reddish.
         CARPETWEED *(Mollugo verticillata)* p. 70

      3. Plants not forming prostrate mats, spreading or erect; flowers in branched or rounded inflorescences; seeds not as above.
         4. Stems spreading or nearly prostrate (decumbent), covered with fine hooked bristles which readily adhere to clothing; fruit separating into 2 globular seeds.
            BEDSTRAW *(Galium* spp.*)* p. 166

         4. Stems erect or ascending, not possessing hooked bristles; fruits many-seeded.
            5. Stems nearly simple (unbranched); flowers in umbels (numerous flower stalks arising from the same place); pods milkweed-like, more than 1 inch long; seeds large, flat, tufted with long hairs.
               WHORLED MILKWEED *(Asclepias verticillata)* p. 134

            5. Stems much branched; flowers in branched inflorescences; fruits a fraction of an inch in length; seeds small, black with a white rim.
               SPURRY *(Spergula arvensis)*

   2. Leaves opposite (uppermost rarely alternate).
      6. Plant a twining or climbing vine; leaves heart-shaped at base; fruits milkweed-like.
         CLIMBING MILKWEED *(Ampelamus albidus)* p. 136

      6. Plants not vines; leaves and fruits various, not as above.
         7. Leaves pinnately lobed (lobed approximately at right angles to midrib of blade); mature fruits (capsules) hanging downward; plants evident in spring.
            NYCTELEA *(Ellisia nyctelea)*

         7. Leaves various, not as above; mature fruits not hanging down; plants flowering at various times of the season.
            8. Leaves entire (edge without teeth), or (rarely) the lowermost toothed; flowers not borne in heads; fruits frequently containing several seeds.
               9. Long bristles (stipules) present at leaf bases; fruits splitting into 2 or 3 large seed-like fragments, each with 3 or 4 scale-like appendages at tip.
                  BUTTONWEED *(Diodia teres)* p. 166

9. Stipules not present; seeds not as above described, released from within fruits at maturity.
   10. Flowers borne in the axils of conspicuous alternate bracts (reduced leaves); plants appearing fleshy; fruits somewhat 2-lobed.
   PURSLANE SPEEDWELL *(Veronica peregrina)* p. 161

   10. Flowers not borne in the axils of alternate bracts; bracts and leaves all opposite; plants not fleshy; fruits not 2-lobed.
      11. Plants with a milky juice; fruit long and slender, shaped somewhat like a pencil; seeds with a tuft of long fine hairs.
      DOGBANE *(Apocynum cannabinum)*

      11. Plants not possessing a milky juice; fruit short; seeds without hairs.
         12. Plants low or creeping, rarely more than a few inches high; flowers 1/8 inch or less in diameter.
            13. Lower leaves stalked (petioled); plants hairy only on angles of stems and leaf stalks.
            CHICKWEED *(Stellaria media)* p. 69

            13. Leaves without stalks (sessile); plants densely hairy all over.
            MOUSE-EAR CHICKWEED *(Cerastium vulgatum)* p. 69

         12. Plants erect, frequently exceeding 1 foot in height; flowers usually 1/2 inch or more across.
            14. Plants glabrous (not hairy).
               15. Stem sticky; fruit (capsule) surrounded by a tight-fitting hull (calyx); plant annual.
               SLEEPY CATCHFLY *(Silene antirrhina)* p. 65

               15. Stem not sticky; capsule surrounded by swollen, bladdery calyx hull; plant perennial.
               BLADDER CAMPION *(Silene cucubalus)* p. 66

            14. Plants hairy (pubescent).
               16. Stems sticky, or viscid-hairy; styles (branches of the stalk from the pistil) 3 in number; plant annual, with single stout stem.
               NIGHT-FLOWERING CATCHFLY *(Silene noctiflora)* p. 64

               16. Stems soft-hairy, not sticky or viscid; styles 5 in number; plant biennial or perennial, with several stems from its base. WHITE CAMPION *(Lychnis alba)* p. 63

8. Leaves toothed or lobed; flowers in dense clusters (frequently in heads which appear superficially like single flowers), or spikes; fruits not capsules.

17. Leaves lobed, the lower somewhat maple-like; flower clusters becoming spiny in fruit.
MOTHERWORT *(Leonurus cardiaca)* p. 146

17. Leaves toothed; flower spikes or clusters not becoming spiny in fruit.
18. Flowers in spikes or in dense clusters in leaf axils; fruits splitting into four 1-seeded segments; stems conspicuously square.
19. Flowers in spikes terminating stems.
20. Flowers closely overlapping in dense spikes; plants aromatic (leaves with a strong odor when crushed); seeds (nutlets) with a pair of white spots at base.
CATNIP *(Nepeta cataria)* p. 144

20. Flowers not closely crowded, in loose, narrow spikes, the fruits especially well separated and not at all overlapping; plants not aromatic; seeds without a pair of white spots at base.
WHITE VERVAIN *(Verbena urticaefolia)* p. 148

19. Flowers in dense clusters in leaf axils along the stem, not terminating it. WILD MINT *(Mentha arvensis)*

18. Flowers in small heads which appear somewhat like individual flowers; fruits 1-seeded (achenes), topped by a fine cluster of hairs or scales; stems not conspicuously square.
21. Flower heads with white petal-like marginal (ray) flowers and a yellow center; leaves with one main midvein; plants annual.
GALINSOGA *(Galinsoga parviflora)*

21. Flower heads entirely white; leaves with 3 main veins; plants perennial.
22. Leaves broadly lanceolate, finely hairy; clusters of small leaves usually present in the axils of the main blades; heads usually with fewer than 15 flowers.
BONESET *(Eupatorium serotinum)*

22. Leaves ovate, tapering to a point (acuminate), not hairy; clusters of small leaves not present in axils of main blades; heads usually with more than 15 flowers.
WHITE SNAKEROOT *(Eupatorium rugosum)* p. 306

1. Leaves alternate or sometimes most of them in a basal cluster (rosette).
23. Leaves, stems, or both prickly or spiny.
24. Flowers more than 2 inches in diameter; leaves with prickly teeth along edge.
PRICKLY POPPY *(Argomone polyanthemos)* p. 95

24. Flowers less than 1 inch in diameter; stem and leaf surfaces with yellowish thorns. HORSENETTLE *(Solanum carolinense)* p. 157

23. Leaves and stems not spiny, but fruits sometimes prickly or spiny.
25. Petals 4, placed at right angles to one another and presenting a cross-like appearance; fruits several-seeded.
26. Fruits flat.
27. Fruit triangular; plant covered with tiny, branched (stellate) hairs. SHEPHERD'S-PURSE *(Capsella bursa-pastoris)* p. 84

27. Fruit circular; plants smooth or with unbranched hairs.
28. Fruit about 1/2 inch in diameter; seeds dark brown; leaves toothed. PENNYCRESS *(Thlaspi arvense)* p. 87

28. Fruit 1/8 inch or less in diameter; seeds reddish-yellow; lower leaves pinnatifid (irregularly lobed, with lobes more or less at right angles to long midrib).
PEPPERGRASS *(Lepidium virginicum)* p. 86

26. Fruits inflated on one or both sides, or globular.
29. Plants densely hairy.
30. Pods short-cylindric, twice as long as wide; leaves entire (not toothed). HOARY ALYSSUM *(Berteroa incana)* p. 84

30. Pods circular or broadly elliptic in outline, nearly as broad as long; leaves wavy-toothed or the lower somewhat lobed.
31. Plants perennial from creeping roots; pods inflated on both sides, with a distinct beak at tip.
PERENNIAL PEPPERGRASS *(Cardaria draba)* p. 85

31. Plants annual; pods flat on one side, inflated on the other, with little or no beak.
FIELD PEPPERGRASS *(Lepidium campestre)* p. 87

29. Plants without hairs (glabrous) or with inconspicuous hairs.
32. Pods well over 1/4 inch long, with a short beak (about 1/4 the length of pod); seeds about 1/10 inch long.
LARGE-SEEDED FALSE FLAX *(Camelina sativa)*

32. Pods 1/4 inch or less long, with a somewhat longer beak (about half the length of pod); seeds less than 1/16 inch long.
FALSE FLAX *(Camelina microcarpa)* p. 78

25. Petals not 4 in number or if so (rarely), not placed at right angles to one another; fruits various.
33. Plants vine-like, trailing, twining, or climbing; leaves heart- or arrowhead-shaped (cordate, hastate, or sagittate), or palmately lobed (lobes all originating near base of blade).

34. Plants climbing by tendrils; flowers small, in dense, branched clusters; fruits fleshy.
WILD CUCUMBER *(Echinocystis lobata)*

34. Plants not possessing tendrils; flowers large, or small in axillary clusters.
35. Flowers clustered in upper leaf axils, greenish-white, not morning glory-like; fruit resembling a buckwheat seed, 3-angled, 1-seeded, not splitting open at maturity (indehiscent); young stems with membranous sheaths (ochreae) at attachment of leaf blades. WILD BUCKWHEAT *(Polygonum convolvulus)* p. 46

35. Flowers large, morning glory-like, fruit a capsule, ripening several large seeds; young stems without membranous sheaths at attachment of leaf blades.
36. Leaves deeply 3-lobed.
IVY-LEAVED MORNING GLORY *(Ipomoea hederacea)* p. 139

36. Leaves not deeply lobed, usually heart- or arrowhead-shaped (cordate or sagittate).
37. Leaves arrowhead-shaped (sagittate or hastate) with pointed basal projections; plants perennial from slender creeping rootstocks.
38. Flowers roughly the size of a quarter; leaves tending to oblong with narrow basal lobes, the blade continuing in essentially the same direction as the leaf stalk (petiole); plants more often trailing than climbing.
FIELD BINDWEED *(Convolvulus arvensis)* p. 138

38. Flowers about the size of a silver dollar; leaves tending to be triangular with broad, basal lobes, the blade bent back at right angles to the petiole; plants twining and climbing.
HEDGE BINDWEED *(Convolvulus sepium)* p. 138

37. Leaves heart-shaped (cordate) with rounded basal lobes; plants annual or perennial.
39. Flowers about 2 inches broad, not dark purple inside; plants annual, twining.
MORNING GLORY *(Ipomoea purpurea)* p. 139

39. Flowers frequently 3 inches broad, dark purple inside of tube; plants perennial from very large roots, usually trailing on ground.
WILD SWEET POTATO *(Ipomoea pandurata)*

33. Plants erect, ascending, or sometimes prostrate, but not vine-like; leaves various, usually not as above.

40. Leaves (especially the lower ones) deeply palmately cleft (lobes directed, finger-like, to base of blade) or palmately compound, the segments in turn toothed or cleft.
  41. Leaf segments closely crowded together, the blade as a whole nearly circular in outline; flowers not possessing a purple center; fruit slender and pointed.
      CRANESBILL *(Geranium carolinianum)* p. 114

  41. Leaf segments not crowded together, the blade not circular in outline; flowers with a purple center; fruit nearly as thick as long.
      SHOOFLY *(Hibiscus trionum)* p. 123

40. Leaves various, not palmately cleft or palmately compound.
  42. Leaves pinnately compound (leaflets arising from an elongated midrib), or dissected into fine segments.
    43. Flowers in compound umbels (borne in carrot-like fashion with numerous flower stalks arising from about the same point); fruits longitudinally ribbed, splitting into two 1-seeded segments at maturity.
      44. Fruits bristly; plant hairy; leaves finely divided, fern-like in appearance, the ultimate segments scarcely more than 1/16 inch wide. WILD CARROT *(Daucus carota)* p. 127

      44. Fruits not bristly; plant smooth, without hairs; leaves not fern-like, leaflets 1/8 to 1/2 inch wide.
          WATER HEMLOCK *(Cicuta maculata)* p. 128

    43. Flowers in heads (which look somewhat like individual flowers), or in a spike; fruits various, not as above.
      45. Leaves compound with about 13 to 15 entire (not toothed) leaflets; flowers in a spike-like cluster (raceme); fruit a bur-like prickly pod. WILD LICORICE *(Glycyrrhiza lepidota)* p. 96

      45. Leaves dissected into fine, fern-like segments; flowers in flower-like heads; fruit not a bur-like pod; plants usually strong-scented.
        46. Flower heads yellow in center, approaching 1 inch in width; leaves bright green, not densely hairy.
            MAYWEED *(Anthemis cotula)* p. 197

        46. Flower heads gray-white, smaller than above; leaves densely hairy or smooth.
          47. Flower heads erect in a flat-topped cluster rising above the leaves; plants usually hairy, perennial from a tangle of short rootstocks.
              YARROW *(Achillea millefolium)* p. 197

47. Flower heads usually drooping from leafy, spreading, or ascending branches; plants hairy or smooth, perennial or annual.
  48. Plant smooth, annual, pleasantly aromatic.
  WORMWOOD *(Artemisia annua)*

  48. Plant silky or woolly-hairy, perennial.
  MUGWORT *(Artemisia absinthium)*

42. Leaves simple, not compound or dissected.
  49. Plants with a strong, onion-like odor, arising from a fleshy bulb; leaves fleshy, narrowly linear, mostly arising at or near base of stem; flowers umbellate (numerous flower stalks arising in close proximity).
    50. Leaves mostly in a cluster at ground level.
    WILD ONION *(Allium canadense)* p. 241

    50. Leaves borne on stem as well as at ground level.
    WILD GARLIC *(Allium vineale)* p. 240

  49. Plants and flowers various, not as above.
    51. Stems and leaves (at least on lower surface) gray- or white-woolly; flowers in white or gray-white cottony heads which look like individual flowers.
      52. Leaves spoon-shaped, mostly borne in basal clusters (rosettes) or on horizontal stolons (prostrate stems); heads dirty white, in small, erect clusters.
      PUSSY'S-TOES *(Antennaria plantaginifolia)* p. 187

      52. Leaves lanceolate, borne on an erect stem; heads clean white, frequently in rather dense clusters.
      CUDWEED *(Gnaphalium obtusifolium)* p. 195

    51. Stems and leaves not woolly; flowers or flower heads various, not as above.
      53. Flowers in heads having a yellow center (tubular flowers) and white petal-like marginal (ray) flowers.
        54. Heads more than 1 inch across; basal leaves oblong or irregularly spoon-shaped, lobed (pinnatifid) or toothed with more or less rounded segments.
        OXEYE DAISY *(Chrysanthemum leucanthemum)* p. 199

        54. Flower heads less than 1 inch in diameter; leaves various, not as above.
          55. Plants perennial from horizontal rootstocks, flowering in early fall; stems ordinarily bearing clusters of reduced leaves in axils of main blades, frequently considerably

branched below inflorescence; flower heads often borne from one side of spreading or nearly horizontal inflorescence branches.[5]

56. Flower heads mostly 1/2 inch or more across; involucral bracts tending to be rolled up lengthwise at tip; stems glabrous or stiffly hairy, branched mostly in inflorescence.
ASTER *(Aster pilosus)* p. 198

56. Flower heads mostly less than 1/2 inch across; involucral bracts not rolled up, often bent backwards; stems usually finely fuzzy (pubescent), diffusely branched throughout.
ASTER *(Aster ericoides)*

55. Plants annual or biennial from taproots, flowering in summer or fall; axillary clusters of reduced leaves not present; flower heads on erect ascending branches in dense or flat-topped clusters.

57. Flower heads about 1/4 inch or less across, numerous in a dense, ellipsoidal cluster (panicle); stem usually unbranched below inflorescence, very closely leafy with crowded, strap-shaped blades.
HORSEWEED *(Erigeron canadensis)* p. 200

57. Flower heads 1/2 inch or more across in a flat-topped cluster (corymb); stem branched or unbranched, loosely leafy with well-spaced, oblong to ovate, frequently toothed blades.

58. Stem hairs conspicuous, spreading; stem leaves mostly toothed, the lowermost strongly toothed or shallowly lobed.
DAISY FLEABANE *(Erigeron annuus)* p. 201

58. Stem hairs inconspicuous, upwardly appressed against stem (strigose); leaves, except for the lower, mostly untoothed.
DAISY FLEABANE *(Erigeron strigosus)*

53. Flowers not in heads, or if in head-like clusters, not colored as above described.

59. Leaves entire, neither toothed nor lobed.

60. Fruit a fleshy berry, purplish when mature, bearing black, shiny seeds; leaves borne on distinct stalks (petioled); plants often 3 feet or more high.
POKEWEED *(Phytolacca americana)* p. 60

60. Fruit dry; seeds not as above; leaves narrowed to base, but without a distinct petiole; plants usually less than 3 feet high.

61. Plants prostrate or ascending, usually less than 1 foot tall, not possessing a milky juice; flowers inconspicuous, in leaf axils; fruits 1-seeded, triangular.

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[5] The following leads distinguish two common kinds of Asters. Several other species may occur as roadside or pasture weeds and will key out here.

62. Plants prostrate, forming flat mats or ascending at tips; or completely ascending, but usually only a few inches high; leaves blue-green, oblong to narrowly elliptic; a very common weed.
KNOTWEED *(Polygonum aviculare)* p. 45

62. Plants ascending, frequently about 1 foot high; leaves yellow-green, elliptic to broadly elliptic, less common than above.
ERECT KNOTWEED *(Polygonum erectum)*

61. Plants erect, usually more than 1 foot high, with a milky juice; flowers in terminal clusters; fruits 3-lobed, 3-seeded capsules.
63. Plants annual; leaves, especially upper, with a white margin and greenish center; flower clusters small, somewhat hidden by the leaves; fruits hairy.
SNOW-ON-THE-MOUNTAIN *(Euphorbia marginata)* p. 109

63. Plants perennial; leaves all green; flower clusters conspicuous, white; fruits smooth.
FLOWERING SPURGE *(Euphorbia corollata)* p. 106

59. Leaves toothed or lobed.
64. Leaves as broad as or broader than long, roughly circular in outline with a basal notch; fruits circular, dry, when mature breaking into several 1-seeded, wedge-shaped segments.
ROUND-LEAVED MALLOW *(Malva neglecta)* p. 124

64. Leaves and fruits various, not as above.
65. Fruit a small berry, black when mature, green when immature; flowers look like tiny potato flowers; leaves wavy-toothed or shallowly lobed, almost always with insect holes.
BLACK NIGHTSHADE *(Solanum nigrum)* p. 158

65. Fruit a capsule, dry when mature; flowers not like potato flowers; leaves variable, some of them usually lobed or pinnatifid; insect injury usually not obvious.
66. Plants low or sprawling, flowering in early spring; leaves all deeply pinnatifid; capsule hairy, with 4 large seeds.
NYCTELEA *(Ellisia nyctelea)*

66. Plants erect, flowering in summer and fall; leaves variously lobed or toothed; capsules not as above.
67. Flowers large, 3 to 5 inches long; fruits large, spiny; plants rank, much branched, frequently becoming 5 feet high.
JIMSON WEED *(Datura stramonium)* p. 159

67. Flowers much smaller than above; fruits small, smooth; plants little branched, usually not more than 4 feet high.
MOTH MULLEIN *(Verbascum blattaria)* p. 160

KEY 3. PLANTS WITH RED, PINK, BLUE, LAVENDER, OR PURPLE FLOWERS

1. Plants (leaves, stems) spiny or thorny.
   2. Leaves opposite. TEASEL *(Dipsacus sylvestris)*

   2. Leaves alternate.
      3. Leaves attached directly to stem (sessile), edges prickly; flowers in dense, globular, flower-like, prickly heads; fruit seed-like, dry; plants erect, 1 to 6 feet tall, little branched with the main axis (stem) predominant, thistle-like.
         4. Stems white-woolly.
            WOOLLY THISTLE *(Cirsium flodmani)*

         4. Stems green (often pubescent but hairs not forming a white blanket).
            5. Plants perennial from creeping roots, with stems usually 2 to 3 feet high, crowded together; flower heads lavender, not prickly, up to 1 inch across (frequently less) when in flower.
               CANADIAN THISTLE *(Cirsium arvense)* p. 191

            5. Plants biennial, with taller stems (2 1/2 to 6 feet high), often well separated; flower heads purple, prickly, more than 1 inch across when in flower.
               6. Head very large, 1 1/2 inches or more across, solitary, usually on a distinct stalk which is bent or somewhat recurved; plants flowering in midsummer (July).
                  MUSK THISTLE *(Carduus nutans)* p. 193

               6. Heads less than 1 1/2 inches across, usually several, scarcely stalked above uppermost leaves; plants flowering in late summer (August-September).
                  7. Leaves white underneath; stems not prickly; plants often 6 feet high.
                     TALL THISTLE *(Cirsium altissimum)* p. 190

                  7. Leaves green underneath; stems prickly; plants usually 3 to 4 feet high.
                     BULL THISTLE *(Cirsium vulgare)* pp. 190, 192

      3. Leaves attached to stem with slender stalks (petioles), edges not prickly; prickles restricted to stems, leaf petioles, and veins; flowers separate, resembling potato flowers; fruit a berry; plants rarely more than 1 1/2 feet tall, branched and spreading.
         8. Plants white-hairy; leaves lanceolate to oblong, wavy-margined but not lobed; flowers blue-purple.
            WHITE HORSENETTLE *(Solanum elaeagnifolium)* p. 156

8. Plants greenish; leaves ovate to lanceolate, frequently lobed; flowers usually light lavender.
HORSENETTLE *(Solanum carolinense)* p. 157

1. Plants (leaves, stems) not spiny or thorny (fruits or fruit clusters sometimes spiny).
9. Leaves opposite (the uppermost rarely alternate).
10. Leaves entire, without teeth or lobes along the margin.[6]
11. Flowers in dense globe-like clusters; fruit a soft pod, several inches long; juice milky.
COMMON MILKWEED *(Asclepias syriaca)* p. 133

11. Flowers not in globe-like clusters; fruits smaller than above; juice not milky.
12. Plants creeping with short, erect, flowering branches at most a few inches high.
13. Flowers not hidden by broad, overlapping bracts.
THYME-LEAVED SPEEDWELL *(Veronica serpyllifolia)*

13. Flowers partly hidden by broad, overlapping bracts.
HEAL-ALL *(Prunella vulgaris)* p. 144

12. Plants erect, 6 inches to several feet in height.
14. Leaves stalked (petioled); fruits 1-seeded or breaking into four 1-seeded segments (nutlets).
15. Leaves somewhat heart-shaped (cordate); plants usually about 2 feet high; flowers 2 or 3 together, borne above a membranous "umbrella" (involucre).
WILD FOUR O'CLOCK *(Mirabilis nyctaginea)* p. 59

15. Leaves not cordate; plants frequently less than 1 foot high; flowers borne in a dense spike, and partly hidden by broad, overlapping bracts.
HEAL-ALL *(Prunella vulgaris)* p. 144

14. Leaves not stalked (sessile); fruits many-seeded capsules.
16. Plant hairy; flowers purple-red, not crowded together.
CORNCOCKLE *(Agrostemma githago)* p. 67

16. Plants smooth; flowers pinkish, usually crowded together.
17. Calyx (the green hull around the base of the flower) tubular, round in cross-section; plants perennial.
BOUNCING BET *(Saponaria officinalis)* p. 68

17. Calyx becoming swollen, angular in cross-section; plants annual. COW COCKLE *(Saponaria vaccaria)*

[6] Two weeds in this group may have both entire and toothed leaves on the same plant. They are keyed out in both directions, i.e., under this "10" as well as the "10" following.

10. Leaves toothed or lobed along the margin, not entire.
  18. Leaves cut nearly to the midrib (pinnatifid) into toothed segments or lobes; plants low, spreading, or nearly prostrate.
      PROSTRATE VERVAIN *(Verbena bracteata)* p. 147

  18. Leaves toothed or lobed (usually in palmate or finger-like fashion) but the incisions not extending to midrib; plants usually either erect or strictly prostrate and rooting at nodes.
    19. Plants prostrate, usually ascending at the tip, or with short erect branches.
      20. Flowers borne usually 2 or 3 together in axils of ordinary foliage leaves; uppermost leaf pairs sessile and grown together (connate) at base.
        21. Stems extensively trailing; leaves smooth, frequently broader than long; seeds with a white spot at base.
            GROUND IVY *(Glechoma hederacea)*

        21. Stems short, prostrate to low ascending; leaves finely hairy, frequently longer than broad; seeds without white spot at base. HENBIT *(Lamium amplexicaule)* p. 145

      20. Flowers borne in short erect spikes in the axils of bracts or reduced leaves; uppermost leaves not connate.
        22. Stems extensively trailing; flowers borne in the axils of narrow, alternate bracts.
            THYME-LEAVED SPEEDWELL *(Veronica serpyllifolia)*

        22. Stems short, trailing or entirely erect; flowers borne in the axils of very broad bracts, and almost hidden from external view. HEAL-ALL *(Prunella vulgaris)* p. 144

    19. Plants erect or ascending.
      23. Flowers in dense clusters in the axils of foliage leaves.
        24. Lower leaves maple-like, broad and palmately lobed; flower clusters becoming spiny in fruit.
            MOTHERWORT *(Leonurus cardiaca)* p. 146

        24. Lower leaves not as above, ovate to lanceolate and toothed; flower clusters not becoming spiny.
            WILD MINT *(Mentha arvensis)*

      23. Flowers in spikes, terminating stems above leaves.
        25. Bracts accompanying flowers broad and very conspicuous.
            HEAL-ALL *(Prunella vulgaris)* p. 144

        25. Bracts narrow or inevident.
          26. Flowers pink to lavender, 1/2 inch or more in length.
              DRAGONHEAD *(Dracocephalum parviflorum)*

26. Flowers blue, usually less than 1/2 inch in length.
 27. Leaves distantly toothed, narrowly oblong or lanceolate; flowers well spaced in the spike (may be crowded in bud), the fruits not overlapping.
 LANCE-LEAVED SAGE *(Salvia reflexa)*

 27. Leaves closely toothed, ovate or broadly lanceolate; flowers in dense spikes; fruits closely overlapping.
  28. Plants 2 to 3 feet high, little branched except for cluster of spikes at top; leaves very hairy; flowers 1/4 inch across.
  HOARY VERVAIN *(Verbena stricta)* p. 147

  28. Plants frequently 3 to 4 feet high, often branched; leaves inconspicuously hairy; flowers less than 1/4 inch across.
  BLUE VERVAIN *(Verbena hastata)* p. 149

9. Leaves alternate or mostly in a basal cluster.
 29. Leaves compound with entire leaflets.
  30. Leaves pinnately compound, terminated by tendrils; flowers pea-like (but considerably smaller).
  VETCH *(Vicia villosa)* p. 100

  30. Leaves palmately compound, not possessing tendrils; flowers not pea-like. BEE-PLANT *(Cleome serrulata)*

 29. Leaves various, rarely compound (if so with lobed or toothed leaflets).
  31. Plants vine-like, trailing, twining, or climbing; leaves with a pair of downwardly or outwardly pointed basal lobes (cordate, sagittate, or hastate), or main body of blade divided into 3 segments.
   32. Fruit a berry with numerous small, flat seeds; flowers similar to potato flowers; plant irregularly sprawling, scarcely twining, often woody at base, frequently with leaves of several shapes. BITTER NIGHTSHADE *(Solanum dulcamara)*

   32. Fruit a dry capsule with few, large seeds; flowers morning glory-like; plants prostrate or climbing, not woody at base; leaves on a single plant consistent in shape.
    33. Flowers pinkish to lavender; leaves with the basal corners (lobes) pointed, these lobes sticking outward or downward (sagittate or hastate); plants perennial from slender rootstocks.
     34. Flowers roughly the size of a quarter; leaves tending to be oblong with narrow basal lobes, the blade continuing in essentially the same direction as the leaf stalk (petiole); plants more frequently trailing than climbing.
     FIELD BINDWEED *(Convolvulus arvensis)* p. 138

34. Flowers roughly the size of a silver dollar; leaves tending to be triangular with broad basal lobes, the blade bent back at right angles to the petiole; plants twining and climbing.
HEDGE BINDWEED *(Convolvulus sepium)* p. 138

33. Flowers usually deep purple or blue; leaves cordate with rounded basal lobes or deeply 3-lobed; plants annual.
35. Leaves heart-shaped (cordate); calyx lobes (the lobes of the greenish hull at the base of the flower) abruptly pointed, relatively short.
ANNUAL MORNING GLORY *(Ipomoea purpurea)* p. 139

35. Leaves deeply 3-lobed; calyx lobes slender, drawn-out, and gradually tapering to point (attenuate).
IVY-LEAVED MORNING GLORY *(Ipomoea hederacea)* p. 139

31. Plants various, sometimes trailing, but not vine-like; leaves various, not as above.
36. Leaves about as broad as long, roughly circular in outline (although sometimes lobed into numerous segments); flowers pink to lavender, relatively small and inconspicuous; plants spreading or low ascending.
37. Leaf blades finger-like (palmately) dissected into lobed segments; fruit extended into a pointed beak.
WILD CRANESBILL *(Geranium carolinianum)* p. 114

37. Leaf blades irregularly scalloped or shallowly lobed; fruit flat.
ROUND-LEAVED MALLOW *(Malva neglecta)* p. 124

36. Leaves longer than broad, not circular; flowers and plants various.
38. Stems encircled by short membranous sheaths (ochreae) just above the attachment of each leaf; flowers bright pink, or reddish to salmon-pink in short spikes; leaf blades entire; mature seeds black, smooth.
39. Plants perennial from slender creeping roots; stems and leaves covered with fine, close appressed hairs; plants usually growing in wet or poorly drained soil, especially along roadside ditches.
DEVIL'S SHOESTRING *(Polygonum coccineum)* p. 47

39. Plants annual; stems and leaves smooth; plants common in all kinds of soil.
40. Flowers bright rose or pink; stem sheaths (ochreae) smooth or torn at the top; flowers and seeds distinctly larger than in the following species—hulled seeds are about 1/8 inch long. PENNSYLVANIA SMARTWEED
(Polygonum pensylvanicum) pp. 43, 44

40. Flowers dull pink to salmon-pink; ochreae topped by a line of hairs (ciliate); hulled seeds much less than 1/8 inch long.
LADYSTHUMB *(Polygonum persicaria)* p. 42

38. Stems not possessing ochreae; flowers usually blue to purple or lavender; if pinkish, in globular, flower-like heads; leaves and seeds various, usually not as above.

41. Fruit a berry; flowers similar to potato flowers; plant reclining or sprawling, somewhat woody at base; leaves heart-shaped or 2-lobed at base. BITTER NIGHTSHADE *(Solanum dulcamara)*

41. Fruit dry, not a berry; flowers not resembling potato flowers; plants erect or ascending; leaves not as above.

42. Fruits (or bur-like hulls enclosing a cluster of fruits) spiny or prickly.

43. Fruits breaking into 4 1-seeded segments at maturity, much less than an inch in length.

44. Flowers blue, small, about 1/8 inch across; leaves narrow.
STICK-SEED *(Lappula echinata)* p. 150

44. Flowers reddish to reddish-purple, 1/4 to 1/2 an inch across; lower leaves large and broad.
HOUNDS-TONGUE *(Cynoglossum officinale)*

43. Fruits or fruit-containing burs enclosing numerous seeds (or 1-seeded fruits), an inch more-or-less in length.

45. Flowers large, 2 to 5 inches long; fruit a capsule, prickly with short, straight spines, bearing numerous rounded or kidney-shaped seeds; leaves irregularly wavy-toothed or lobed. JIMSON WEED *(Datura stramonium)* p. 159

45. Flowers smaller than above, aggregated into bur-like heads about 1 inch long; burs soft-prickly with hooked bristles, bearing several oblong 1-seeded fruits (achenes); leaves mostly entire. BURDOCK *(Arctium minus)* p. 187

42. Fruits not prickly.

46. Inflorescence an unbranched spike; flowers large with 5 petals; fruit a many-seeded capsule.
BELL-FLOWER *(Campanula rapunculoides)*

46. Inflorescence various, branched; flowers small, in flower-like heads; fruits 1-seeded achenes, several to a head.

47. Plants with a milky juice; individual flowers in the head strap-shaped and petal-like.

48. Flowers pink; leaves small, entire; stem conspicuously ridged, the upper portion practically leafless.
SKELETON WEED *(Lygodesmia juncea)*

48. Flowers blue; leaves (at least the basal ones) large, pinnatifid or coarsely toothed; stem not conspicuously ridged.
 49. Plant with numerous well-developed stem leaves, the upper narrowly strap-shaped and entire (usually with no teeth); stems straight, ordinarily branched only at top; seeds (achenes) flattened with a short beak.
 BLUE LETTUCE *(Lactuca pulchella)*

 49. Plant with well-developed leaves mostly at base, the upper reduced; stem much branched; achenes neither flattened nor beaked. CHICORY *(Cichorium intybus)* p. 181

47. Plants not possessing a milky juice; individual flowers tubular, not petal-like.
 50. Flower heads 1/2 inch or more across; lower leaves pinnatifid or irregularly toothed, the upper essentially entire or with slender divisions; plants usually less than 3 feet high.
 51. Plants perennial from creeping roots; heads not dark-spotted on outside; seeds (achenes) ivory-colored, without a crown of bristles at top. RUSSIAN KNAPWEED *(Centaurea repens)* p. 189

 51. Plants biennial from a taproot; heads dark-spotted on outside; achenes dark, with an oblique notch at base and a crown of bristles at top.
 SPOTTED KNAPWEED *(Centaurea maculosa)* p. 189

 50. Flower heads about 1/4 inch across; lower and upper leaves essentially similar with numerous even teeth; plants often exceeding 3 feet. IRONWEED *(Vernonia* spp.*)* p. 196

KEY 4. PLANTS WITH GREENISH FLOWERS

1. Plants grass-like; leaf blades sessile (without a stalk or petiole) and attached to a sheath which encircles the stem; blades narrowly strap-shaped, entire (without teeth or lobes), with numerous parallel veins.
   2. Plants with a strong onion-like odor, arising from a fleshy bulb, bearing clusters of small scaly bulblets below flowers.
      3. Leaves mostly in a cluster at ground level.
         WILD ONION *(Allium canadense)* p. 241

      3. Leaves borne on stem as well as at ground level.
         WILD GARLIC *(Allium vineale)* p. 240

   2. Plants not possessing an onion-like odor, not bearing aerial bulblets.
      4. Stems triangular in cross-section; leaves harsh and somewhat stiff, arising in 3 rows.
         5. Plants arising from heavy, creeping rhizomes (underground stems); fruits borne in broad spikes; seeds (1-seeded fruits) produced within an inflated, sac-like structure (perigynium).
            SEDGE *(Carex* spp.*)*[7] p. 238

         5. Plants with slender, string-like rhizomes and small tubers; fruits borne in narrow, clustered yellowish-green spikes; seeds (1-seeded fruits) hidden by closely overlapping bracts, but not in sac-like structures.
            YELLOW NUTGRASS *(Cyperus esculentus)* p. 239

      4. Stems not triangular in cross-section, round or flattened; leaves various, usually arising in 2 rows from opposite sides of the stem.
         6. Fruit a spiny bur.
            SANDBUR *(Cenchrus pauciflorus)* p. 216

         6. Fruit not a spiny bur.
            7. Plants low and wiry, rarely found in cultivated soil; flowers numerous in nearly flat-topped clusters (cymes) with tiny green petals and sepals; fruits bearing many very small, dust-like seeds. RUSH *(Juncus tenuis)* p. 239

            7. Plants various; flowers not in flat-topped clusters, without petals and sepals, usually hidden from external view by

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[7] A number of sedges (*Carex* spp.) may occur as agricultural weeds. They are usually conspicuous in the spring, growing in wet, low meadows and along ditches. They are rare in agricultural soil. All species of *Carex* have the seed borne within the sac-like perigynium. The size, appearance, and arrangement of the perigynia are extremely variable.

enclosing hulls; fruit (the grain) 1-seeded, much larger than above.
(GRASSES)[8]

8. Stem or its main branches terminated by a single flowering spike (like wheat or quackgrass); spikes neither borne in clusters at stem tip nor arising from leaf axils along the stem.
   9. Seeds (spikelets), when "shucked" from the spike, rounded or elliptic in outline, not sharply pointed or terminated by a bristle; spikes usually dense and cylindric, very bristly from clusters of stiff hairs which surround the seeds (but which are not borne by the seed hulls).
      10. Spikes with fine "stickers" and readily adhering to clothing or hands if touched; plant of local abundance.
      BRISTLY FOXTAIL *(Setaria verticillata)* p. 222

      10. Spikes neither stickery nor adherent.
         11. Seeds (spikelets) broadly oval, 1/8 inch or more long; hard inner hull (lemma) coarsely cross-wrinkled; bristles tawny yellow; a few long, slender hairs present on upper side of blade at base; sheaths not finely hairy (ciliate) along overlapping margins.
         YELLOW FOXTAIL *(Setaria lutescens)* p. 222

         11. Seeds (spikelets) narrowly oval, less than 1/8 inch long; inner hull (lemma) granular or faintly cross-wrinkled; bristles green or pale yellow when dry; leaves without hairs on upper surface, or entirely covered with fine, short hairs; sheath marginally hairy, or ciliate (hand lens will help).
            12. Leaves without hairs (glabrous) on upper surface; spikes erect or slightly drooping at tip; plants usually less than 3 feet high. GREEN FOXTAIL *(Setaria viridis)*[9] p. 221

            12. Leaves finely hairy on upper surface; spikes drooping at tip; plants sometimes up to 6 feet high.
            GIANT FOXTAIL *(Setaria faberii)* p. 221

   9. Seeds (spikelets or florets), when "shucked" from spike, oblong to lanceolate, pointed at tip (or entire spike fragmenting into seed-containing bony joints—see GOATGRASS, lead 13); hulls frequently terminated by bristles; spikes various, bristly or not bristly.

[8] Although many grasses are easily recognized, it is difficult to identify them in a key without the use of technical characteristics. This key, avoiding the use of exact (and more technical) terms, is necessarily less precise than if such terms were employed. Reference to the illustrations (pages 216 to 235) may facilitate keying grasses.

[9] This weed appears to cross with foxtail millet (*Setaria italica*). The hybrids are common in some areas and may be much taller than the above, with lobed, somewhat drooping spikes.

13. Spike axis with hard, bony joints, the seeds contained within these joints; bristles few in number, 3 or 4 long ones protruding from tip of spikes, the ones below becoming progressively shorter to base; plant occurring mostly in southern part of our range.
GOATGRASS *(Aegilops cylindrica)* p. 220

13. Spike axis not as above; seed-bearing units produced in various manners but not inside of joints of spike axis.
  14. Spikes dense, bristly or plume-like with numerous bristles arising between the seeds (florets) as well as from the tips of them; bristles mostly considerably longer than the seeds.
    15. Spikes plume-like with numerous very long, green or silvery bristles protruding in all directions.
    SQUIRREL-TAIL GRASS *(Hordeum jubatum)* p. 218

    15. Spikes stiff (like a small head of barley) with rigid, ascending bristles about as long as or slightly longer than the seeds.
    WILD BARLEY *(Hordeum pusillum)* p. 219

  14. Spikes looser, the seed-bearing units (spikelets) usually clearly separate from one another; bristles absent, or, if present, relatively short, and arising only from the tips of the seeds.
    16.. Seed-bearing units (spikelets) placed with narrow edge against spike axis; plants annual, primarily grain-field weeds.
    DARNEL *(Lolium temulentum)*

    16. Seed-bearing units (spikelets) placed with the broader, flat edge against spike axis; plants perennial from scaly, creeping rootstocks, abundant throughout most of north-central states.
    QUACKGRASS *(Agropyron repens)* p. 216

8. Stems not terminated by a single spike; inflorescences various—if spikelike, the spikes borne in leaf axils along stem or clustered together in finger-like fashion at tip.
  17. Inflorescence of 2 to 5 spikes which arise in finger-like fashion from tip of stems; bristles (awns) not present.
    18. Plants perennial with short ascending branches arising from extensively creeping stolons (prostrate stems); leaves at base of erect branches much reduced; seed-bearing units (spikelets) not hairy, 1-seeded.
    BERMUDA GRASS *(Cynodon dactylon)* p. 225

    18. Plants annual, ascending or sprawling and rooting from lower nodes; none of leaves reduced; spikelets finely hairy or several-seeded.
      19. Spikes mostly less than 1/8 inch wide; seed-bearing units (spikelets) finely hairy, 1-seeded; a fine row of hairs (ligule) present at base of upper side of blade where it joins the sheath.

20. Stems and leaf sheaths hairy; seeds (spikelets) narrowly oval, the inner hull brownish.
CRABGRASS *(Digitaria sanguinalis)* p. 223

20. Stems and leaf sheaths almost without hairs; spikelets broadly oval, the inner hull (when mature) black.
SMOOTH CRABGRASS *(Digitaria ischaemum)* p. 223

19. Spikes broader than 1/8 inch; spikelets smooth, bearing several seeds; ligule a fine membrane rather than a row of hairs.
GOOSEGRASS *(Eleusine indica)* p. 224

17. Inflorescences not of 2 to 5 spikes, or if spike-like, bristly or long-hairy.
21. Seed-bearing units (spikelets) without bristles (awns).
22. Spikelets oblong, several-seeded, with several or numerous hulls (lemmas) overlapping in shingle-like fashion.
23. Spikelets not strongly flattened, with about 6 overlapping hulls; leaves without glands.
ANNUAL BLUEGRASS *(Poa annua)*

23. Spikelets conspicuously flattened, with more than 10 overlapping hulls; leaves with small, bumpy glands, especially along edges (a hand lens may be needed for these distinctions).
LOVEGRASS *(Eragrostis cilianensis)*[10] p. 229

22. Spikelets oval, 1-seeded, without a series of shingle-like hulls.
24. Inflorescences diffusely branched (a panicle), the spikelets well separated from one another at the tips of the ultimate branchlets; plants annuals.
25. Plant erect or ascending, densely hairy.
WITCHGRASS *(Panicum capillare)* p. 234

25. Plant prostrate-spreading or ascending, smooth.
FALL PANICUM *(Panicum dichotomiflorum)* p. 235

24. Inflorescences slender, appearing almost spike-like (the branches ascending and pressed together), or the spikelets irregularly congested.
26. Seed heads sticking up beyond leaves, irregularly congested and lopsided, or consisting of an aggregation of short spikelets each shelling down to a hard, shiny hull which is nearly as broad as long; plant annual, husky, with stems usually more than 1/4 inch in diameter.
BARNYARD GRASS *(Echinochloa crusgalli)* p. 233

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[10] Some two additional species of *Eragrostis* are common late-summer, waste area or roadside weeds, usually in dry soil.

26. Seed heads usually overtopped by some of the leaves, not lopsided but narrow and spike-like in appearance; spikelets about twice as long as broad.
    27. Plants perennial, robust from scaly rootstocks; seed head (panicle) evident; usually a weed of moist, fertile soils.
    MUHLY GRASS *(Muhlenbergia frondosa)*

    27. Plants annual, very slender, without rootstocks; seed head very slender, spike-like, often nearly hidden in upper leaf sheaths; a weed usually of dry sterile areas.
    DROPSEED GRASS *(Sporobolus neglectus)*

21. Spikelets with short or long bristles or awns.
    28. Inflorescences with dense, long silky hairs, appearing like a series of separate or somewhat congested plumes; lower portion of the stem flattened with somewhat keeled edges; plants perennial. BROOMSEDGE *(Andropogon virginicus)* p. 231

    28. Inflorescences not silky-hairy; pubescence (hairs), if present, relatively short; plants various.
        29. Bristles (awns) 3-branched (shorter unbranched bristles may also be present). TRIPLE-AWN GRASS *(Aristida oligantha)* p. 236

        29. Awns unbranched.
            30. Some or all of awns spirally twisted at base.
                31. Awn 3 to 4 inches long, several times length of seed, frequently twisted for much of its length.
                PORCUPINE GRASS *(Stipa spartea)*

                31. Awn scarcely exceeding 1 inch in length, up to about twice the length of seeds, usually twisted near the base.
                    32. Spikelets about 3/4 inch long (excluding awns), gaping open at the tip when mature, 2- to 3-seeded; seeds (florets) oblong, dull gray to black; plants annual, oat-like in appearance. WILD OATS *(Avena fatua)* p. 228

                    32. Spikelets (excluding awns) about 1/4 inch long, not opening at tip, 1-seeded; seeds (spikelets) plump, elliptic, straw-colored to shiny black; plants perennial from stout creeping rootstocks, resembling sudan grass, occurring only in southern part of our range.
                    JOHNSON GRASS *(Sorghum halepense)* p. 232

            30. Awns not spirally twisted.
                33. Inflorescence open-branched (a panicle) but occasionally appearing somewhat plume-like, the spikelets usually well separated from one another; spikelets large, oblong, 1/2 to 3/4 inch in length (excluding awns), with a series of hulls

overlapping in shingle-like fashion and breaking into several seeds at maturity.

34. Stems essentially smooth and without hairs; awns usually rather short. CHEAT *(Bromus secalinus)* p. 227

34. Stems finely hairy; awns long and conspicuous.

35. Spikelets and seeds finely hairy; panicle rather dense, frequently turning reddish-purple at maturity and appearing plume-like.
DOWNY BROMEGRASS *(Bromus tectorum)* p. 226

35. Spikelets and seeds not hairy; panicle more open, neither becoming reddish nor appearing plume-like.
JAPANESE BROME *(Bromus japonicus)* p. 226

33. Inflorescence not open-branched, usually irregularly congested, or very slender, the spikelets crowded together; spikelets broadly or narrowly elliptic, 1-seeded, less than 1/2 inch long (excluding awns).

36. Plants husky, growing in the open, the stems usually more than 1/4 inch in diameter; inflorescence an irregular, often lopsided cluster of spikelets, or forming a series of short, dense spikes; spikelets broadly rounded, often covered with short bristles; annual. BARNYARD GRASS *(Echinochloa crusgalli)* p. 233

36. Plants running along ground and rooting at the joints; slender, frequently growing in partial shade, the stem less than 1/4 inch in diameter; inflorescence long and narrow; spikelets small, narrowly elliptic; perennial.
NIMBLEWILL *(Muhlenbergia schreberi)* p. 230

1. Plants neither grasses nor grass-like; leaves without a basal sheath; blades frequently stalked (petioled), various in shape, often toothed, lobed, or compound, not parallel-veined, but with a main vein and branches (pinnately veined), or 3 to 5 main veins from base of blade (palmately veined), the interspaces net-veined.

37. Stem not leaf-bearing; leaves all in a basal cluster (rosette) at ground level.

38. Leaves broadly ovate or elliptic; flower-producing portion of spike longer than stalk (peduncle); seeds irregular in shape, several in each seed pod (capsule).

39. Leaves glossy green, almost without hairs; petioles usually purple at base; seeds black when mature (but immature ones brownish). RUGELS PLANTAIN *(Plantago rugellii)* p. 165

39. Leaves dull green or gray-green, covered with fine hairs; petioles not purple; seeds brown when mature.
COMMON PLANTAIN *(Plantago major)* p. 164

38. Leaves lanceolate to linear; flower-producing portion of spike about as long as, or much shorter than peduncle; seeds 2 in each capsule, hollowed out on one side and boat-shaped.

40. Plants perennial, usually appearing smooth; leaves narrowly elliptic to lance-shaped; flowering spike less than 1/5 as long as stalk (peduncle); mature seeds glossy, without a white line on the concave surface.
BUCKHORN PLANTAIN *(Plantago lanceolata)* p. 163

40. Plants annual; usually appearing hairy or woolly; leaves narrowly oblong to linear; flowering spike 1/2 as long or nearly as long as peduncle; mature seeds not glossy, with an elliptic, white line on concave surface.

41. Bracts much longer than flowers and giving the spike a bristly appearance; plants loosely hairy (villous) or occasionally nearly smooth, most common in the southern part of our range.
BRACTED PLANTAIN *(Plantago aristata)* p. 162

41. Bracts mostly shorter than flowers and hidden by them; entire plant, including spike, woolly, most common in western portion of our range.
WOOLLY PLANTAIN *(Plantago purshii)* p. 164

37. Stem leaf-bearing with opposite or alternate blades at time of flowering (a basal rosette of leaves may or may not also be present).

42. Leaves palmately compound with 5 to 7 narrow leaflets arising finger-like from the same point at the end of the leaf stalk.
HEMP *(Cannabis sativa)* p. 38

42. Leaves various, not palmately compound.

43. Leaves fern-like, divided into numerous, narrow segments (1- or 2-pinnatifid); plants ragweed-like, topped by a spike (raceme) of yellowish-green, sterile, pollen-producing flowers (flower heads).

44. Leaves woolly beneath or on both sides; fruit a spiny bur, usually with 2 or 3 seeds; plants primarily of western portion of our range.

45. Leaves woolly beneath; stamen-producing flowers (flower heads) short-stalked; fruits with straight spines.
BUR RAGWEED *(Franseria discolor)* p. 178

45. Leaves woolly on both sides; stamen-producing flowers (flower heads) slender-stalked; fruits with curved spines.
BUR RAGWEED *(Franseria tomentosa)*

44. Leaves not woolly; fruit 1-seeded, not a spiny bur; plants abundant throughout our range.

46. Plants annual, very common; leaves smooth above, usually much divided, the main segments being cut into secondary divisions (2-pinnatifid); fruits with a distinct crown of points at tip.
COMMON RAGWEED *(Ambrosia elatior)* p. 176

46. Plants perennial from creeping roots (first-year plants appear annual), very similar in general appearance to above, but much less common; leaves rough on upper surface, less divided than in above species, the main segments frequently lobed but not again divided (1-pinnatifid); fruits with a very short crown of points or nearly smooth at tip.
PERENNIAL RAGWEED *(Ambrosia psilostachya)* p. 177

43. Leaves not fern-like; entire, toothed, or lobed but not pinnatifid; plants various.

47. Plant a twining vine; mature fruits (after husk is rubbed off) black.
WILD BUCKWHEAT *(Polygonum convolvulus)* p. 46

47. Plant not a twining vine; fruits brown.

48. Stem encircled by a white or brownish membranous sheath (ochrea) for a short distance just above attachment of each leaf (this sheath is easily seen on younger parts of stem—it is frequently broken and partly destroyed on older portions); seeds (achenes) 3-angled.

49. Plants with a basal rosette of leaves as well as stem leaves (rosette blades may mostly be gone on old plants); flowers in a terminal spike; seeds (achenes) shiny.

50. Leaves arrowhead-shaped (hastate) with pointed basal lobes; plants with creeping rootstocks; fruit hulls (calyx lobes) tightly appressed to fruit.
SHEEP SORREL *(Rumex acetosella)* p. 40

50. Leaves not hastate; plants not possessing creeping rootstocks; fruit hulls loose around fruit.

51. Leaves smooth and even, neither closely wavy along margin nor lobed at base; fruiting hulls, when mature, about 1/4 inch long.
SMOOTH DOCK *(Rumex altissimus)* p. 40

51. Leaves either closely wavy-crisped along margin or slightly basally lobed (cordate); fruiting hulls less than 1/4 inch long.

52. Leaves ovate to oblong, mostly somewhat cordate at base, frequently with reddish veins; fruit hulls toothed along margin.
BROAD-LEAVED DOCK *(Rumex obtusifolius)* p. 41

52. Leaves oblong, with crisped or wavy-curved edges, rarely red-veined; fruit hulls not toothed.
SOUR DOCK *(Rumex crispus)* p. 39

49. Plants not possessing a basal rosette; flowers axillary; seeds (achenes) usually dull.
53. Plants prostrate, forming flat mats or ascending at tips, or completely ascending, but only a few inches high; leaves blue-green, oblong to narrowly elliptic; a very common weed.
KNOTWEED *(Polygonum aviculare)* p. 45

53. Plants ascending, frequently about 1 foot high; leaves yellow-green, elliptic to broadly elliptic; less common as a weed.
ERECT KNOTWEED *(Polygonum erectum)*

48. Stem not encircled by a sheath as above described; fruits various, not as above.
54. Leaves entire, neither toothed nor lobed.
55. Plants spiny.
56. Upper leaves narrow, hardened, and spine-tipped; seeds snail-like in appearance.
RUSSIAN THISTLE *(Salsola kali)* p. 58

56. Leaves all normal, the spines arising in pairs at base of leaf stalks; seeds lens-shaped, black.
SPINY PIGWEED *(Amaranthus spinosus)* p. 53

55. Plants not spiny (fruit sometimes a spiny bur).
57. Plants with a milky juice; leaves without stalks (sessile) or very short-stalked, strap-shaped or oblong; flower clusters yellowish-green or greenish-white.
58. Flowers with small greenish-white petals; leaves with very short stalks; fruit long and slender.
DOGBANE *(Apocynum sibericum)* p. 137

58. Flowers borne above yellowish-green bracts; leaves without stalks, strap-shaped; fruit as wide as long.
59. Leaves about 1/8 inch wide.
CYPRESS SPURGE *(Euphorbia cyparissias)* p. 106

59. Leaves usually 1/4 to 1/2 inch wide.
LEAFY SPURGE *(Euphorbia esula)* p. 105

57. Plants not possessing milky juice; leaves stalked or sessile; flower clusters not yellow-green.
60. Plant prostrate, forming a mat on ground.
PROSTRATE PIGWEED *(Amaranthus graecizans)* p. 52

60. Plants erect or ascending.
  61. Plants woolly.
  GOATWEED *(Croton capitatus)* p. 111

  61. Plants smooth or hairy, but not woolly.
    62. Plants perennial from creeping rootstocks, mostly restricted to western portion of our range; leaves elliptic to oblong, not stalked (sessile), 3-veined; flower clusters borne in leaf axils.
    POVERTY-WEED *(Iva axillaris)* p. 179

    62. Plants annual; widely distributed; leaves various, not as above described; flower clusters (except for bushy-branched *Amaranthus albus*, below) in terminal spikes.
      63. Leaves not stalked (sessile), narrowly strap-shaped (linear) to lanceolate; seed brownish, longer than wide.
      KOCHIA *(Kochia scoparia)* pp. 56, 57

      63. Leaves stalked (petioled), ovate to lanceolate; seeds black when mature, circular.
        64. Plants bushy-branched, the flowers borne in clusters in leaf axils.
        TUMBLING PIGWEED *(Amaranthus albus)* p. 52

        64. Plants little branched with the main axis predominant; flowers in dense terminal spikes.
          65. Spikes dense, bristly in appearance and somewhat prickly to touch; leaves finely hairy, usually broadly lanceolate and upwards of 1/2 inch in width.
            66. Spikes thick, the main portion more than 1/2 inch thick (this plant is not always clearly distinguishable from the following species).
            ROUGH PIGWEED *(Amaranthus retroflexus)* p. 51

            66. Spikes narrow, the main portion less than 1/2 inch across. GREEN PIGWEED *(Amaranthus hybridus)*

          65. Spikes often somewhat interrupted, and not especially dense, not bristly nor prickly to touch; leaves smooth, usually narrowly lanceolate, frequently not more than 1/2 inch wide.
          WATER HEMP *(Acnida* spp.*)* p. 54

54. Leaves not entire, toothed (the teeth sometimes small or scattered) or lobed.
  67. Fruit a bur covered with numerous hooked spines; leaves long-stalked, irregularly shallowly lobed and toothed, rough.
  COCKLEBUR *(Xanthium strumarium)* p. 180

67. Fruit not a spiny bur; leaves various.
  68. Plants with milky juice, rarely more than 1 foot high; leaves frequently with dark blotches or spots, all opposite.
    69. Plants prostrate.
    PROSTRATE SPURGE *(Euphorbia maculata)* p. 107

    69. Plants ascending, usually with slanting stems which frequently recurve at tip. NODDING SPURGE *(Euphorbia nutans)* p. 108

  68. Plants not possessing milky juice; leaves various, not spotted—if all opposite, the plants usually much taller than above described.
    70. Leaves all alternate, the basal ones not opposite.
      71. Fruits produced in irregularly branched spikes which protrude beyond leaves, 1-seeded; seeds lens-shaped, usually black in color after being rubbed to remove scurf; plants not restricted to southern part of range.
        72. Fruits (actually fruits plus enveloping calyx) with a marginal wing; upper portion of stem often nearly naked at maturity; leaves sharply sinuate-toothed; mostly limited to western portion of our range.
        WINGED PIGWEED *(Cycloloma atriplicifolium)*

        72. Fruits not possessing a marginal wing; leaves retained at maturity, i.e., stem not becoming naked; leaves variously toothed; plants not restricted to western portion of north-central states.
          73. Plants strongly aromatic; leaves oblong, wavy-toothed or shallowly lobed, not white-mealy beneath.
          MEXICAN TEA *(Chenopodium ambrosioides)*

          73. Plants not aromatic; leaves ovate to oblong, irregularly lobed, toothed or nearly entire, frequently white-mealy beneath.
            74. Seeds (easily rubbed out of hulls) about 1/16 of an inch in diameter; leaves dull green to green, often scurfy-whitish beneath, the larger blades usually not exceeding 2 to 3 inches in length; common weed.
            LAMBSQUARTER *(Chenopodium album)* p. 55

            74. Seeds 1/16 to 1/8 inch in diameter; leaves bright green, the larger blades often 4 inches or more in length; only locally common.
            MAPLE-LEAVED GOOSEFOOT *(Chenopodium hybridum)*

      71. Fruits solitary or in small clusters at base of upper leaves, frequently mostly hidden by the leaves, forming 2 to 4 seeds;

seeds usually turtle-shaped; plants restricted to southern portion of our range. CROTON *(Croton capitatus)* p. 111

70. Lower leaves opposite, the upper becoming alternate, or all leaves opposite.[11]
  75. Flower clusters produced in leaf axils and not protruding above leafy stem.
    76. Leaves all opposite; stems frequently more than 2 feet high, with stinging hairs; flower clusters slender, catkin-like, drooping from leaf axils. STINGING NETTLE *(Urtica dioica)* p. 38

    76. Leaves mostly alternate, usually with insect holes; stems usually less than 2 feet high, not possessing stinging hairs; flower clusters mostly hidden by toothed bracts in leaf axils. THREE-SEEDED MERCURY *(Acalypha rhomboidea)* p. 110

  75. Flower clusters in simple or branched spikes (racemes or panicles), entirely or in part borne apically on stem above leaves.
    77. Seeds circular in outline, blackish, borne within a pair of pointed husks which fit together in clamshell-like fashion; leaves frequently arrowhead-shaped (hastate). ORACHE *(Atriplex patula)* p. 57

    77. Seeds (fruits) not circular in outline, not borne as above described; leaves not hastate.
      78. Leaves narrow, usually with 1 or 2 upward-pointing teeth on each side; plants low, usually not much more than 1 foot high, restricted to southern portion of our range. LANCE-LEAVED RAGWEED *(Ambrosia bidentata)* p. 177

      78. Leaves broad and large, with numerous teeth, or 3- to 5-lobed; plants tall, frequently more than 3 feet high.
        79. Leaves, except sometimes for the uppermost, 3- to 5-lobed; fruits with a crown of points at tip. GIANT RAGWEED *(Ambrosia trifida)* p. 177

        79. Leaves unlobed; fruits seed-like without a crown of points. MARSH ELDER *(Iva xanthifolia)* p. 179

[11] If lowermost leaves have fallen off, their position can be verified by noting leaf scars at stem nodes.

KEY 5. PLANTS WOODY

WARNING: Poison ivy and poison oak have compound leaves with three leaflets. Don't pick or handle leaves of this type.

1. Plants thorny or spiny.
  2. Leaves simple.
    3. Leaves entire; fruit the size of a large orange, green.
       OSAGE ORANGE *(Maclura pomifera)*

    3. Leaves toothed or lobed; fruits like small crabapples, usually reddish. HAWTHORNS *(Crataegus* spp.*)*

  2. Leaves compound.
    4. Leaflets toothed; shrubby plants.
      5. Stipules fused to petioles; flowers usually pinkish, one inch or more across, rose-like.
         WILD ROSES *(Rosa* spp.*)* p. 93

      5. Stipules essentially free from petioles; flowers usually white, less than one inch across.
         BRAMBLES, WILD BLACKBERRIES (*Rubus* spp.)

    4. Leaflets entire; trees.
      6. Some of leaves twice-compound (i.e., the main divisions of the leaves in turn compound); thorns various, becoming more than one inch long and branched.
         HONEY LOCUST *(Gleditsia triacanthos)*

      6. Leaves all once-compound; thorns (spines) less than one inch in length, unbranched.
         BLACK LOCUST *(Robinia pseudo-acacia)*

1. Plants not thorny or spiny.
  7. Leaves compound.
    8. Leaves opposite.
      9. Plant a vine with trumpet-shaped orange-red flowers, 2 to 3 inches long.
         TRUMPET CREEPER *(Campsis radicans)*

      9. Plants shrubs or trees; flowers small.
        10. Flowers white, in conspicuous flat- or convex-topped clusters (corymbs) appearing in summer; fruit a small fleshy berry; twigs with conspicuous, light-colored bumps (lenticels). ELDERBERRY *(Sambucus* spp.*)*

10. Flowers greenish-yellow, inconspicuous, appearing with or before leaves; fruit dry, winged (a samara); twigs not as above.
  11. Leaflets mostly 5, conspicuously toothed or lobed; young twigs usually with a whitish-waxy covering.
  BOX ELDER *(Acer negundo)*

  11. Leaflets 5 to 7, entire or finely toothed; twigs not whitish waxy. ASHES *(Fraxinus* spp.*)*

8. Leaves alternate.
  12. Leaflets three; fruits berry-like, white; plants trailing, climbing or forming small shrubs (poisonous to touch!).
  POISON IVY, POISON OAK *(Rhus toxicodendron)* pp. 115, 116

  12. Leaflets 5 or more; fruits not white; plants large shrubs or trees.
    13. Fruits small, reddish "berries," in dense clusters at branch tips; leaves mostly with more than 9 leaflets.
    SUMAC *(Rhus* spp.*)*

    13. Fruits hickory nuts; leaves of common kinds with 5 to 7 leaflets. HICKORY *(Carya* spp.*)*

7. Leaves simple, not divided into leaflets.
  14. Plants evergreen, with needle-like or scale-like leaves.
    15. Leaves needle-like, in clusters of 2 to 5; fruit a cone.
    PINES *(Pinus* spp.*)*

    15. Leaves overlapping scales, or on young plants sometimes like short needles (but not in clusters); fruit berry-like.
    CEDAR *(Juniperus virginiana)*

  14. Plants with deciduous leaves (fall off in winter) which are neither scale- nor needle-like.
    16. Leaves opposite.
      17. Leaves broad, palmately lobed; fruit dry.
      MAPLES *(Acer* spp.*)*

      17. Leaves elliptic, entire; fruit a berry.
        18. Stems viny or forming mats on the ground.
        HONEYSUCKLE *(Lonicera japonica)*

        18. Stems erect, plants forming low shrubs.
        BUCKBRUSH *(Symphoricarpos* spp.*)* p. 167

    16. Leaves alternate.
      19. Plants vine-like, trailing or climbing, fruit a berry.
        20. Plants with tendrils; leaves palmately lobed.
        WILD GRAPES *(Vitus* spp.*)*

20. Plants not possessing tendrils; leaves ovate and entire or with 1 or 2 irregular lobes at base; flowers potato-like.
BITTER NIGHTSHADE *(Solanum dulcamara)*

19. Plants shrubs or trees; fruit various, usually not a berry.
21. Leaves lobed.
22. Leaves densely white-hairy beneath.
WHITE POPLAR *(Populus alba)*

22. Leaves not white-hairy underneath.
23. Leaves both lobed and serrate; fruit fleshy; plants with milky juice. MULBERRY *(Morus rubra)*

23. Leaves not serrate; fruit an acorn; juice not milky.
OAKS *(Quercus* spp.*)*

21. Leaves not lobed.
24. Leaves 3 to 5 times as long as wide (in common species); buds covered by a single hood-like scale.
WILLOWS *(Salix* spp.*)*

24. Leaves less than 3 times as long as wide; buds various, usually with several overlapping scales.
25. Leaves palmately veined with 3 (sometimes 5) main veins from base of blade.
26. Leaves lopsided or asymmetric at base; fruit fleshy, 1-seeded; bark usually with distinctive narrow ridges or bumps. HACKBERRY *(Celtis* spp.*)*

26. Leaves essentially symmetric; fruit if fleshy with several seeds.
27. Juice milky; fruits fleshy, several-seeded; leaf petioles scarcely flattened. MULBERRY *(Morus rubra)*

27. Juice not milky; fruits dry with tiny air-borne seeds; petioles often flattened.
COTTONWOODS, POPLARS *(Populus* spp.*)*

25. Leaves pinnately veined, with one main vein from base of blade.
28. Leaves asymmetric at base.
ELMS *(Ulmus* spp.)

28. Leaves symmetric.
29. Leaves nearly as broad as wide, abruptly pointed; petioles flattened; buds sticky.
COTTONWOOD *(Populus* spp.*)*

29. Leaves various but distinctly longer than wide; petioles not flattened; buds not sticky.
  30. Leaf petioles with one or two or sometimes several small glands at upper end; flowers white, conspicuous; fruits fleshy.
  WILD CHERRIES *(Prunus* spp.*)*

  30. Leaf petioles not bearing glands; flowers greenish, some of them in catkins; fruit dry.
    31. Some of leaves crowded together on short spurs; fruits in cone-like clusters. BIRCHES *(Betula* spp.*)*

    31. Leaves alternate, not crowded together; fruit a nut enclosed in a husk. HAZELBRUSH *(Corylus* spp.*)*

Poisonous Weeds

22. Poisonous Weeds

THE MAJOR IMPACT of weeds on agriculture is their effect on crop production. However, certain weed (and crop) species are, in addition, capable of causing discomfort, injury, or death to animals. Man also may be unpleasantly affected by plants; he is subject to hay fever and the irritations or illnesses resulting from contact with dermatitis-causing plants, among which poison ivy is pre-eminent. Domestic animals usually suffer ill effects as a consequence of eating the leaves, stems, or roots of harmful plants, but some weed species may cause mechanical injury. The plants involved are termed poisonous plants.

Herbivorous animals (cows, sheep, horses, pigs) are those most apt to be subject to plant poisoning. Human beings likewise are capable of being poisoned; their chief protection is a difference in eating habits.

Poisonous plants are not a major problem in the production of livestock in most of the central states area. They do constitute a significant economic consideration on the western ranges. This is because: (1) there is a greater prevalence of poisonous species in this part of the country, (2) extensive rather than intensive management practices are the rule; in other words, weed control procedures which are practical on land with a high return per acre may not be economically feasible on the lower value (per acre) ranges, and (3) mismanagement of the ranges. Continued overstocking for decades has resulted in the reduction or destruction of native grassland. This has made possible the invasion of poisonous weeds which would be unable to compete with a vigorous, perennial grass cover.

In general, if food is ample, animals will not eat most poisonous plants, athough there are some exceptions. In many areas poisoning has been on the increase because of the increasing shortage of desirable forages; the animals then turn to plants they would not otherwise touch. The increasing prevalence of poisonous weeds following destruction of grasses likewise favors greater frequency of poisoning.

In some instances losses of cattle and sheep have been suffered while they were being moved from one location to another. Under such circumstances the animals, having no opportunity to browse, are apt to grab a mouthful of any available plant. Plant poisoning may also be experienced if the stock, after having been on the move all day, are held in a relatively limited area for the night. Being hungry, they can rapidly consume all acceptable forage, and then proceed to any other accessible plants.

The effects of plant poisoning are diverse. Sometimes the symptoms are scarcely discernible, being evidenced only by failure to gain or by unthriftiness. In other instances, stock are affected by chronic or prolonged disorders which may or may not result in death. Poisoning from some plants can lead to death within a few minutes' or hours' time. The same species may cause a chronic involvement or, on the other hand, rapid death, depending upon the amount ingested at one time and the conditions under which it was eaten.

Poisoning symptoms are often generalized, and a definitive diagnosis may not be possible on the basis of symptomatology alone. Diagnosis is then frequently dependent upon identification of the plant material involved. If death of the animal has ensued, a post-mortem examination of stomach contents may be made. Otherwise, the pasture or range should be examined for poisonous plants which show signs of having been browsed and whose known injurious effects are consistent with the symptoms observed.

SOME PRINCIPAL TYPES OF PLANT POISONS

Alkaloids

These are basic, nitrogenous organic compounds which are physiologically active. Caffeine, the active ingredient in coffee, is an example. Some have slight effects; some are valuable in medicine but can also be extremely poisonous. Alkaloids are especially prevalent in certain plant families, among them, the Legume *(Leguminosae)*, Lily *(Liliaceae)*, Potato *(Solanaceae)*, and Buttercup *(Ranunculaceae)* families.

Glucosides

These are compounds which, on hydrolysis, break down into glucose plus other substances. They may be toxic in themselves and/or their hydrolytic products may be toxic. If it is the end products which are toxic, poisoning will not necessarily result from the eating of materials containing these substances. Poisoning will, instead, depend upon whether conditions in the animal's stomach favors break-down of the glucosides. Cyanogenetic glucosides (e.g. dhurrin in sorghum, amygdalin in wild cherry) yield the very poisonous HCN on hydrolysis.

Resinoids

This is a general term for alcohol-soluble substances of unknown chemical composition. They are the toxic materials characteristic of various members of the Heath *(Ericaceae)* and Carrot *(Umbelliferae)* families. Presumably the poison hemlock drunk by Socrates was of this type.

Proteinaceous Materials

Also called phytotoxins. Black locust *(Robinia)* and castor bean *(Ricinus)*.

Oxalic Acid and Soluble Oxalates

These cause precipitation of body calcium. They are present in a few members of the Goosefoot *(Chenopodiaceae)* and Smartweed *(Polygonaceae)* families.

Nitrates

Excess nitrates may accumulate in plant tissues under conditions of rich soil and deficient rainfall. Such poisoning has been reported from miscellaneous weeds and oat straw. Cornstalk disease or "green corn" poisoning may be a nitrate effect.

Higher Alcohols

Tremetol from white snakeroot *(Eupatorium)*.

Dicoumarol

An anticoagulant, sometimes formed in spoiled sweet clover.

Selenium

Certain species of locoweed *(Astragalus)* and *Stanleya* have the ability to take inorganic selenium from the soil. Apparently these plants, adapted to regions of the West having seleniferous soils, require selenium in protein synthesis in the place of sulphur. Other plants are not capable of taking up inorganic selenium. However, they (plants in general) are capable of incorporating selenium in the organic form, i.e. from the decomposed remains of selenium-requiring plants. Hence, under such circumstances, a wide variety of plant kinds may be potentially poisonous.

Photosensitization

This effect will result only if (1) animals eat the plants involved, and (2) their skin is subsequently exposed to sunlight. If the skin is protected by a thick coat of hair or is dark-pigmented, symptoms will not develop. Plants which may be responsible include St. Johnswort *(Hypericum)*, buckwheat *(Fagopyrum)*, and rape *(Brassica)*.

Mechanical Injury

The awns of certain grasses can puncture or cause wounds around the face, ears, or in the mouth. If these subsequently become infected, the animal may be in serious condition. Some causative agents: squirrel-tail grass *(Hordeum)*, three-awn grass *(Aristida)*, sandbur *(Cenchrus)*.

SOME POISONOUS PLANTS

Sudan Grass *(Sorghum)*

p232

The principal danger from this forage crop is in summer or fall (forage), or in the winter from hay or silage. The active substance, a cyanogenetic glucoside, dhurrin, is found only in unhealthy plants. Forage injured by frost, drought, or disease is most apt to be dangerous. The availability of enzymes fostering hydrolysis of the glucoside, condition of the animal, and the nature of other material which it has eaten all affect the possibility of HCN being released.

If hay is suspected, it is sometimes suggested that a concentrate be fed first or that maltose or dextrose should be added to the feed. An excess of simple sugars in the stomach will tend to prevent the breakdown of the glucoside.

If active poisoning takes place, death often quickly intervenes and antidotes (oxidizing substances or monosaccharide sugars) are too late.

Wild Cherries *(Prunus)*

p304

Wild cherries are small trees with ovate to elliptic, serrate leaflets, usually with glands on the petiole. The flowers are in conspicuous, white racemes. The fruits are cherry-like, but smaller than cultivated forms.

These plants may, under certain conditions, develop a cyanogenetic glucoside (amygdalin). Wilted leaves are especially dangerous. If trees are cut in a pasture or along a fence row, branches should not be left available to stock. The conditions affecting poisoning are the same as discussed for sudan grass above.

Corncockle *(Agrostemma)* p67

The seeds contain glucosides (or their hydrolytic products) which are poisonous. The seeds may occur in screenings employed in chicken feeds and other mixed feeds. All domestic stock (and humans) may be affected. Pigs are said to be most sensitive but chickens are most frequently poisoned.

Rape *(Brassica)* p305

Rape is a cultivated plant similar in general appearance to the weedy mustards previously described. It is frequently planted for "hog pasture" but may cause photosensitization (blistering and loss of hair) of light-colored hogs.

Sweet Clover *(Melilotus)* p97

In spoiled hay, coumarin may be changed to dicoumarol which slows blood clotting and produces other cumulative effects. Cattle and sheep are more susceptible than horses.

Water Hemlock *(Cicuta)* p128

This plant contains a resinous substance in its cluster of perennial roots. Occasional loss of stock is almost entirely in the spring. At this time of year, when other forage is limited, animals may be attracted to the rosettes of leaves growing in wet soil. The roots are apt to be pulled up and ingested with the leaves.

Black Nightshade *(Solanum)* p158

The leaves, stems, and green fruits contain an alkaloid which may be hydrolyzed to a glucoside. If a sufficient quantity of the weed is eaten, death can ensue in a few hours.

White Snakeroot *(Eupatorium)* p306

White snakeroot is a weed of wooded pastures, thickets, and fence rows. It is much less common than in the past, owing in large part to destruction of its natural habitat. The active ingredient, tremetol, an unsaturated higher alcohol, may be passed to human beings in milk. It causes "trembles" in animals and "milk sickness" in humans. The effects are, in some instances, chronic, or death can take place within a few days after symptoms appear.

Cocklebur *(Xanthium)*

p307

The seedlings in the cotyledon stage are poisonous, especially to pigs.

Barley Scab *(Gibberella)*

Barley scab is a fungus disease usually attacking grains of barley or wheat. Pigs are usually affected; they are intoxicated or narcotized, but usually recover in a few hours. Scab is particularly prevalent on barley in the more humid production areas, and has largely resulted in the restriction of barley production for feed grain purposes to the more arid high plains.

Waterbloom

Waterbloom is a foamy, greenish scum which may develop around the shores of lakes in hot summer. The plants involved are various blue-green algae. Reports of poisoning are sporadic, usually from lake regions, and following periods when the wind has been blowing towards the shore for a considerable length of time. All domestic stock drinking the water may be affected, and may be quickly killed.

Locoweeds *(Astragalus)*

p307

Astragalus, a genus of native wild legumes includes well over 100 species in the United States, the preponderance of them from the plains states west. The plants possess pinnately compound leaves, usually blue to white papilionaceous flowers in spikes or racemes. The fruits are diverse.

Certain species are alkaloid-containing. Others are selenium-indicator plants which, as previously indicated, are not only poisonous in themselves but can release selenium in a form susceptible to being taken up by other plants. Acute selenium poisoning is caused by eating highly seleniferous vegetation and often results in death in a few hours. Blind staggers and alkali disease are chronic forms of selenium poisoning resulting from the more moderate ingestion of mildly seleniferous plants over a period of time.

Larkspur, Poisonweed *(Delphinium)*

p308

The poisonous larkspurs are similar in appearance to the larkspurs and delphiniums of gardens. Their leaves are usually palmately dissected. The flowers are irregular, attractive, and conspicuous. The larkspurs are alkaloid-containing plants and cause losses principally to cattle. They are abundant, Great Plains and West.

Lupines *(Lupinus)*

p309

Lupines are attractive legumes with palmately compound leaves and usually racemes of blue flowers. They are common in the western plains and mountains. The poisoning agents are alkaloids which are especially abundant in the seeds. Sheep are primarily affected.

Halogeton *(Halogeton)*

p308

This weed apparently does not as yet occur in the North Central States. It has, however, become so notorious that it deserves mention.

A member of the Goosefoot family (Chenopodiaceae), it is related to Kochia *(Kochia)* and Russian thistle *(Salsola)*. First reported in the United States about 1935, it is now common in several western states, denuded ranges, waste areas, and roadsides. It is one of the annual weeds which has become prevalent as a consequence of overgrazing of range land.

The plants contain large quantities of soluble oxalates. Sheep are most easily injured. Losses up to several hundred head in a single night have been reported. The use of considerable areas of range has been rendered dangerous because of the presence of this weed.

PLATE 154

Prunus serotina Fruiting branch x2/3.

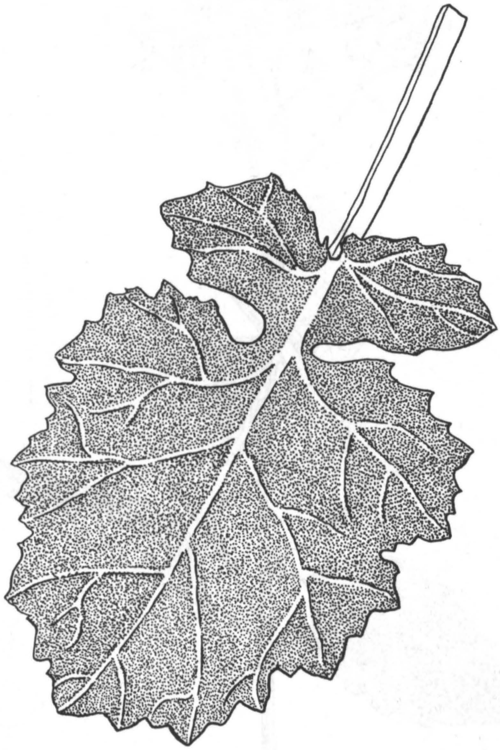

PLATE 155

Brassica napus Leaf x2/3.

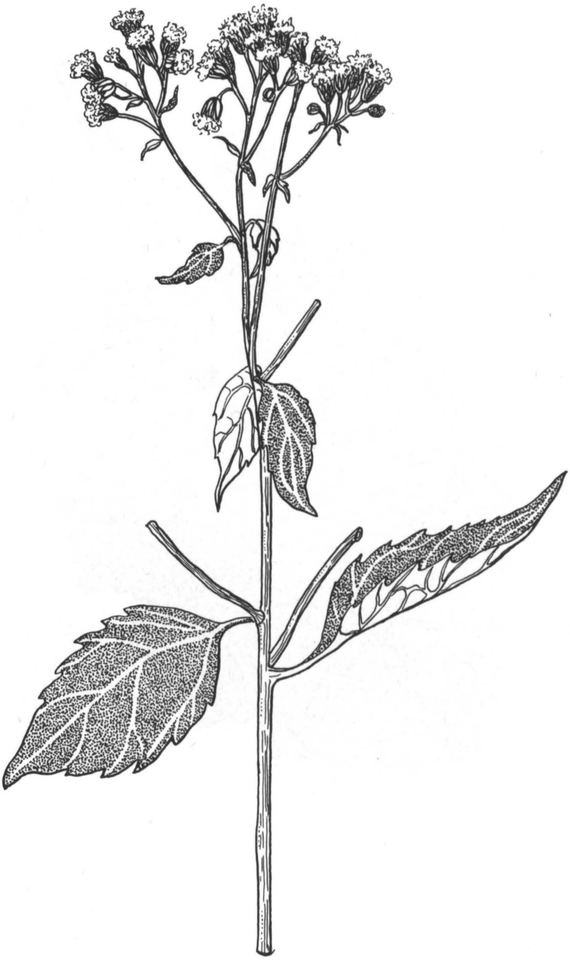

PLATE 156

Eupatorium rugosum Flowering stem x2/3.

PLATE 157

Xanthium strumosum 1. Seedling: first leaves stage x2/3. 2. Seedling: cotyledon stage x2/3.
Astragalus mollissimus 3. Leaf and fruiting raceme x2/3.

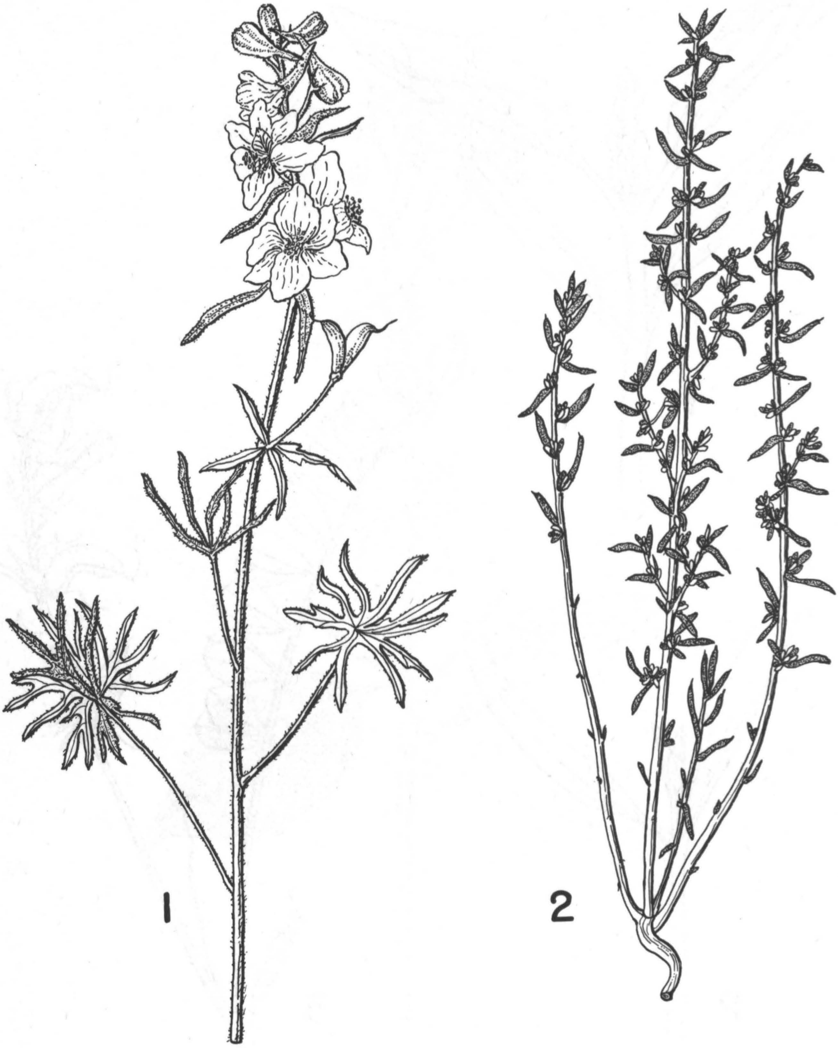

PLATE 158

Delphinium sp. 1. Leaves and inflorescence x2/3.
Halogeton glomeratus 2. Habit x1/3.

PLATE 159

Lupinus sp. Habit x2/3.

Weed Control

23. Weeds and Agriculture: Some Problems and Principles

IMPORTANCE OF WEEDS

Earlier we examined the role of weeds in agriculture. Now, in considering control measures, it may be well to reiterate the economic significance of weeds. Losses due to weeds have been estimated in various ways. It has been said that they cost an annual debt of three to five billion dollars, second only to soil erosion. The average cost of tillage of cultivated land has been estimated at 16 per cent of the value of the crop produced. One half of the tillage required is, in general, due to the presence of weeds. Therefore, on each acre of cultivated land, growers are losing, because of weeds, approximately 8 per cent of the value of the products produced.

Weeds compete with crop plants for light, water, and soil nutrients. The chief role they play in affecting agriculture is that of reducing crop yields as a consequence of such competition. There is some evidence that certain weeds may further reduce crop growth and subsequent yield by releasing inhibitory or poisonous substances into the soil; recent attention has been directed towards quackgrass in this regard. Weeds also increase the cost of labor and equipment, reduce quality of agricultural commodities, harbor insects and fungus diseases, render harvesting more difficult, may be poisonous, cause hay fever, etc.

Weeds can reduce the value of the land or even render it essentially useless for agricultural purposes. In the southwestern United States, literally millions of acres of once valuable range land are covered with almost solid stands of woody plants. A small spiny tree, mesquite, predominates. Practically nothing grows under the dense stands of these plants. The mesquite originally occurred largely along watercourses and in low areas. As a consequence of deterioration of the grassland, resulting from continued overgrazing and drought, this woody plant was able to invade higher ground. Mesquite can be eradicated, but if the land is to be put in operation again, re-establishment of the grasses must follow. The total procedure is difficult from the dollars-and-cents standpoint since control measures may cost as much as the land is worth. Similarly, the introduced *Halogeton* has become very abundant in wide areas of poor condition range. This weed is poisonous to animals. As indicated in the previous chapter, its presence has rendered much semi-arid range dangerous to use.

Another special type of a weed problem occurs in the western states. Water for irrigation is essential to much of agriculture. The weedy vegetation along streams and irrigation canals has the capacity for taking up enormous quantities of water. Estimates place annual water loss in this manner at 25 million acre-feet. Assuming two acre-feet to be required for irrigation purposes per acre during a year, this is enough water to irrigate 12 to 13 million acres of crops.

The exact importance of light, water, and nutrients for which weeds and crop plants compete in a given situation is usually not well known nor, in many instances, how their combined effects result in losses in yields. In instances in which weeds grow rapidly and overshadow crops, it is quite obvious that, aside from other factors, the matter of light is involved. However, weeds reduce yields even though the crop plants are tall enough to obtain sufficient light and there is overabundant moisture and the soil is highly fertile. Possibly water and mineral nutrients become exhausted in an infinite number of small areas in the soil in which root hairs of the weeds and crops are in competition. The following are examples of some of the kinds of observations which have been made regarding the competitive effects of weeds on crops.

Many weeds have a higher water requirement than crops. It has been calculated that 1,000 pounds of cockleburs *(Xanthium)* per acre — not a heavy infestation — require enough water to produce 8 bushels of oats, 7 of barley, 4 of wheat, or 9 of corn. Weeds may have high mineral nutrient requirements. It has been reported that a plant of common mustard *(Brassica)* requires twice as much nitrogen, twice as much phosphorous, four times as much potash, and four times as much water as an oat plant. Work with several weeds has suggested that they are able to absorb potash and nitrogen from the soil better than certain crop plants.

Competition studies with controlled weed stands in carrots, onions, and beets have shown different tolerances on the part of the crop plants to the weeds, and different reactions to specific competition situations. Concentrations as low as 15 per cent of the "normal" stand of weeds were capable of affecting the yield of the crop plants. In fact, in many instances, sparse weed stands caused almost as much damage as denser ones. The period from emergence to four weeks was shown to be a critical stage in competition of weeds with these row crops.

Somewhat the same points are illustrated in an experiment with wheat carried out in South Dakota. Weed-free wheat yielded 42 bushels an acre; wheat infested with 100 mustard plants per square yard yielded 18.4 bushels, and wheat with twice as much mustard yielded 16 bushels per acre. Note that the thin stand of mustard reduced crop yield almost as much as the heavy stand. But wheat that was sprayed in the 4- and 6-leaf stage yielded 40 bushels. However, six days after the 6-leaf stage (wheat in the "flag-leaf" stage and mustard budding), spraying did not materially increase yield. Apparently the principal effect of the mustard occurred before it started to bloom. Spraying after this time facilitated harvesting but did not increase yield.

Recent studies of sorghum (Kansas) have indicated that with moderate rainfall, one weed per two linear feet of row, reduced yield 40 per cent. In a season with very low rainfall, one weed per three feet of row essentially eliminated yield whereas, the weed-free control produced about 20 bushels an acre.

WHAT CHARACTERS MAKE FOR "WORST" WEEDS?

Worst weeds can be defined in several ways. Over-all considerations should probably involve (1) competitive ability, i.e. effect per acre, (2) how widespread, i.e. how many acres does it cover, and (3) how hard it is to get rid of. In the usual definition of worst weeds in which the perennial noxious weeds are considered the major pests, primary emphasis is given to point number three. Total consideration of all three points would probably indicate that some of the abundant, highly competitive annual weeds (e.g. foxtails, *Setaria;* smartweeds, *Polygonum*) have considerably more economic significance than the perennial noxious weeds.

WEED PREVENTION

The cheapest way to control weeds is not to have them in the first place. Weed seeds have been hauled all over the earth with agricultural products and equipment. Most of our weeds are introduced. For instance, in Iowa, only one of the eight primary noxious weeds (horse nettle) in the Agricultural Seed Law is native to the North American continent. The spread of many of the resistant deep-rooted perennials still continues in agricultural seed, manure, feeds, harvesting equipment, nursery stock, and soil. The avoidance of new infestations from such sources is still the farmers' cheapest weed control.

High quality commercial seed which has been recleaned by experienced operators and offered for sale by seedsmen is, in most cases, relatively free of weed seed. But, in certain crops (e.g. oats) much or most of the seed planted never passes through the seedsman's hands. Farmers save their own seed or buy from a neighbor. Such farm seed, as indicated by drill-box surveys, is often fantastically full of weed seeds, containing hundreds or even thousands per pound.

Seed processing equipment used by skilled operators can achieve amazing results in the cleaning of seeds. These are complicated and expensive machines beyond the reach of the ordinary farmer. But many seed companies, elevators, and cooperatives will do custom cleaning for farmers. In general, one or several are within easy hauling distance of any farm.

Weed prevention involves avoiding planting new weeds or replanting hordes of the old ones. It is a basic cornerstone of good farming practice. The value of subsequent weed control practices may be largely negated by planting weed-polluted seed. Specifically, weed prevention involves the following:

(1) If seed is purchased from a seedsman, the higher priced, higher quality seed is usually to be recommended. Ordinarily, it is cheapest in the long run. The purchaser should examine the analysis tag as well as the price tag.

(2) If seed is purchased from a neighbor, the potential purchaser should insist that the seed be tested before the deal is closed.

(3) If a farmer intends to plant his own seed, it will pay him to have it custom-cleaned and tested for noxious weeds, total weed seed content, and germination before planting.

GROWTH HABITS OF WEEDS AS RELATED TO CONTROL PRINCIPLES

Annuals and Biennials

Annuals and biennials live one or two years respectively and reproduce only by seed. New plants must come from seeds. Control, then, involves the use of clean crop seed, and the prevention of seed production by the weeds. Applicable methods may involve mowing, cultivation, competition (including rotations), or the use of herbicides. Complete prevention of seed production will not mean the absence of annual weeds the following year since weed seeds already in the soil will continue to come up; however, if seed production is prevented for several years in succession, a considerable reduction in weeds will result. True, some weed seeds may be carried in by wind or other natural means, but the number of these is usually small as compared to those produced on the land. A simultaneous program (e.g. preplanting working of the soil; pre-emergence herbicides) to induce germination and destruction of seedlings in the soil will speed the program.

Perennials

Since perennial weeds are capable of reproducing from year to year from underground roots or stems, even if no seeds are produced, a weed control program must consider both (1) prevention of seed production and (2) the destruction or starving of underground parts. Direct destruction by chemicals or tillage is often feasible with shallow-rooted perennials like quackgrass *(Agropyron)*. On the other hand, with deeper-rooted weeds (e.g. field bindweed, *Convolvulus*), starvation through exhaustion of the root reserves is often the only economic or practical procedure. This may be accomplished by repeated destruction of the tops (mowing, cultivation, chemicals), or by hampering the ability of the plants to replenish the roots (smother crops).

Work with several perennial noxious weeds has demonstrated that plants draw on their food reserves as they initiate growth in the spring, and this continues, in most cases, until flowering time. After flowering, photosynthesis gains the upper hand as active growth diminishes. Stored foods then build up until the end of the season. In other words, food reserves are frequently at their lowest level shortly before flowering.

The above suggests that initiation of control measures (i.e. destruction of tops) when plants come into bud will catch them when they are weakest. An attractive generalization derived therefrom would be that suppression measures should be started at this time, that earlier destruction of tops may not only be superfluous, but may inhibit reduction of root reserves during rapid preflowering growth of the plant.

We do not have sufficient information to formulate definitive conclusions regarding the timing of initial cultivation (or other control measures) with respect to depletion of stored foods in the underground parts. Active work in this area was initiated in the 1930's, but was largely abandoned in the 1940's when major attention was directed towards herbicides. Published conclusions are not in agreement. In any event, it is to be expected that perennial weeds should exhibit considerable variability in this regard.

On the basis of present evidence, it appears probable that weeds which grow vigorously in the spring and come rapidly into bloom (e.g. leafy spruge, *Euphorbia;* Canadian thistle, *Cirsium;* perennial sowthistle, *Sonchus*) are to a large extent drawing upon stored food during this period, and that control measures prior to this time will not materially accelerate an eradication program. On the other hand, slower developing and later flowering kinds (e.g. perennial peppergrass, *Cardaria;* Russian knapweed, *Centaurea;* horsenettle, *Solanum*) develop sufficient photosynthetic capacity to begin restoring carbohydrate and nitrogen reserves well before coming into bloom. Destruction of plant growth should accordingly be initiated considerably earlier for these species.

Subsequent control measures continued throughout the season are calculated not only to prevent the weed from replenishing food reserves but to deplete them further. To this end, regrowth is destroyed as it emerges or shortly thereafter. A slogan once used with respect to combating perennial weeds was "keep the soil black," i.e. destroy new sprouts immediately on emergence. This probably was not the best advice. Perhaps a week will be required for new shoots to appear again above the ground. But the plant is still drawing more food from its roots than it can replace. Another week or so will be required before sufficient leaf surface is expanded so the photosynthetic output will overbalance food utilization. Only then is destruction of the shoot essential. For instance, weekly cultivations of bindweed have been recommended. As good, or better, results (in terms of total length of the program) can be obtained with cultivations spaced at 14-day intervals.

Many considerations with respect to cropping practices may, of course, affect timing of specific operations. Insofar as possible, however, adherence to the above principles will speed a program to eradicate perennial weeds. Control efforts often fail because: (1) It is not recognized that perennial weeds may possess sufficient food reserves to keep them going for 2 to 3 years, and control practices must be maintained for this length of time. Often efforts are halted just short of success. (2) Control efforts are interrupted for a month in the summer. With even a short period of active growth (and commensurate photosynthetic activity) at this time of the year, the weed stand can do much in a short time to regain lost ground as far as stored food is concerned.

Possibly the above implies that deep-rooted perennials can be controlled only through application of techniques aimed to starve the plants. This is not entirely true. Soil sterilant chemicals and some translocated chemicals are reasonably effective in killing underground parts as well as tops. The number and usefulness of such chemicals can be expected to increase in the future. As yet, sterilants are too expensive to use on large areas and render the soil temporarily unfit for cropping. Weakening or starvation of underground parts still plays an important role in the solution of many perennial weed problems.

24. Weed Control Methods

This and the following chapter develop the subject of weed control on the basis of methodology. Subsequent chapters consider control problems by crop kinds, and in terms of specific weeds.

A multi-directional appraisal inevitably involves a certain overlapping of subject matter. For example, Canadian thistle *(Cirsium)* is discussed as one of the relatively important weed kinds in the North Central states. It also receives attention with respect to an elaboration of the usefulness of various herbicides (e.g. amino triazole); likewise, one can scarcely evaluate weed problems in certain crops without treating the role of this weed. Possibly this results in some redundancy; if so, the author presents no apology. Our subject is not susceptible to a linear approach.

CLASSIFICATION OF WEED CONTROL METHODS

Control methods will be considered under the following headings: (1) Mechanical, e.g. cultivation and mowing, (2) cultural or cropping, (3) burning, (4) biological, (5) chemical (treated in the following chapter).

Control procedures ordinarily involve mechanical, cultural, and chemical methodology. Discussion of these items separately does not imply that certain weeds are controlled by one method to the exclusion of others; usually a combination is employed. Farming necessarily involves a cropping procedure and cultivation. Most weeds can be controlled by the intelligent use of ordinary farming procedures.

MECHANICAL METHODS

Seed Bed Preparation

Seed bed preparation is of principal significance in the control of annual weeds. Its purpose is to reduce weed seed populations in the upper soil layers, prior to the planting of the crop. Plowing is followed by repeated shallow disking or harrowing, and may be carried out at

7- to 10-day intervals. The germination of weed seeds is stimulated and seedlings are destroyed. Such a procedure is especially advisable if an area is badly infested with annual weeds, in which case a late planted crop such as soybeans will allow the land to be repeatedly worked beforehand.

Some recent studies have questioned the effectiveness of repeated preplanting cultivations, and to this extent a definitive position on this topic may not be in order. Most weed control specialists appear to feel that further evidence is desirable before any extensive modification in the above concept is justifiable.

Cultivation

If annuals are the principal consideration, cultivation should be shallow (also for quackgrass) in order to avoid damaging crop roots and so as not to bring up further weed seeds from lower levels of the soil. The rotary hoe, discussed below, is especially valuable for seedlings of annual weeds.

Following harvest of small grains, weed infestations in the stubble sometimes become serious. In some instances, disking or harrowing to destroy the weeds and prevent seed production may be advisable. This may involve the decision as to whether maintenance of a legume understory or destruction of the weeds is most important.

With respect to the majority of perennials, cultivations should be timed, insofar as possible, to catch root reserves at the low point. This applies both to the seasonal cycle as previously discussed and the depletion of reserves after cutting. In general, cultivation is aimed to cut roots three to four inches below the soil surface. As previously discussed, a week may be required for plants to re-emerge and another week before sufficient foliage has developed so that food is produced faster than it is used for growth. Precise rate of emergence naturally depends upon the season and differs between weeds. Nothing is usually gained if cultivations are closer than at two-week intervals; under unfavorable growth conditions three weeks may be better.

Shallowly rooted perennials (e.g. quackgrass) may be subjected to starvation procedures as above described, or alternatively, the rhizomes may be amenable to destruction. The infestation or sod should first be disked to cut up the rootstocks and to facilitate subsequent cultivation. Succeeding operations should be carried out at regular intervals with a spring-tooth harrow even if there is little regrowth. The net result is that the root and rhizome system will be brought to the surface where a large proportion of the fragments will dry up and die. This procedure can follow removal of a grain crop or can be carried out in grassland. Its effectiveness can, in the latter situation, be increased if the area is heavily grazed or mowed prior to treatment.

Fallowing

Summer fallowing to conserve moisture is an accepted practice in much of the more arid portions of the Great Plains. It can also be employed as a method of controlling perennial noxious weeds without the complications of integrating control procedures with practices necessary to get a crop off the land. Fallowing usually is not recommended in the more humid portions of the North Central states. It is ordinarily possible to grow some kind of a crop at the same time the weed control is progressing.

Chemical summer fallows are receiving experimental attention in some of the western states.

Cultivation Tools

The use of the plow is followed by the employment of several kinds of implements which, by working the soil, keep subsequent weed growth down.

The rotary hoe is especially useful for small annual weeds in corn and soybeans. Its utilization when the crop and weed seedlings are small will reduce the number of cultivations needed with sweep or shovel cultivators. The rotary hoe consists of spoked disks with hooks around the margin. These (the hooks) will uproot small seedlings if the soil moisture is right and if the machine is pulled at proper speeds (usually 10 to 12 miles per hour). The hoe will not destroy well-established weeds or deep-rooted perennials. Its greatest usefulness with corn extends from pre-emergence until the crop is 2 to 8 inches high. The operation has been estimated to cost \$0.60 to \$1.00 an acre (depending on whether 2 or 4 row) and thus costs less than shovel cultivation, \$1.05 to \$1.35 per acre; also it can be completed much more rapidly.

Contrary to the above, some workers express reservations concerning the rotary hoe. They point out that the requirements of precise timing and crusting of soil surface are difficult to fulfill, and that if these conditions are not right, inadequate weed control will result. The value of the rotary hoe is limited to annual weeds. In crops like sorghum, considerable stand injury may ensue.

The duck foot cultivator is effective against perennial weeds. The sweeps should overlap three to four inches. The spring-tooth cultivator or harrow operated at a depth of two to three inches is also effective against such weeds.

Mowing

Mowing is pertinent for areas not subject to cultivation, e.g. pastures, hayfields, roadsides. Subsequent to small grain harvest, mowing may be the most applicable procedure to prevent seed formation by late season weed infestations. If properly timed, mowing can essentially prevent seed production of annuals and progressively weaken perennials.

Hand Operations

Hand operations, hoeing, spudding, or spraying scattered plants may nip an incipient infestation in the bud. Also, hand removal of the last survivors after a weed stand has essentially been brought under control is often necessary if eradication is desired. The hoe is still king in the home garden. Furthermore, probably more than half the total production of food in the world is still dependent on hand operations for weed control.

CULTURAL OR CROPPING METHODS

Competition

When weeds and crop plants grow together they compete for light, water, and mineral nutrients. Weeds are frequently successful because, under many conditions, they are better competitors than crop plants. However, farming practices are capable of affecting the degree to which crop plants can successfully compete with weeds. Strong germinating seed will give the crop a vigorous, close stand which, with a head start on the weeds, may make it difficult for them to get underway. On the other hand, poor seed, resulting in a spotty stand, will leave open areas in which the weeds will take over, ultimately dominating adjacent crop plants and reducing yield. Some crops are much better competitors than others, and the choice in terms of the weed situation will greatly influence the outcome. For instance, crops like sudan grass and soybeans are good competitors, while flax is relatively poor. Highly competitive crops are often planted for the primary purpose of reducing weed infestations. Varieties which are well-adapted to a given growing region will obviously compete better than poorly adapted varieties.

Management practices such as proper fertilization, liming if necessary, etc., are important as weed control measures as well as for their direct effect upon potential yield. Many weeds are capable of thriving under low fertility conditions while the crop plants are not. Increased fertility shifts the competitive balance in favor of the crop. An additional factor affecting weed-crop competition is grazing. Overgrazing is a basic cause of weedy pastures. Animals prefer selected grasses and legumes to weeds; if overgrazed, the ability of the forage species to compete with the weeds will be severely reduced. The reduction of the grazing value of our western ranges, together with the widespread invasion of annual weeds and the increased prevalence of poisonous species, is a consequence of overgrazing over a period of years.

Smother Crops

Most frequently employed smother crops include forage sorghums, sudan grass, soybeans (best in solid stands), alfalfa, or on bottom land, reed canary grass. Recommendations for the control or the reduction of many of our noxious weeds involve a clean cultivation followed by the use of a smother crop. In this way it is possible to get a crop from the land and reduce the weed problem simultaneously.

Smother crops have limitations, and decisions regarding their employment may be governed by a number of factors. Soybeans are good competitors after well established but, in their early stages of growth, need help from cultivation. The use of sorghum or sudan may be impractical if facilities for storing silage are not available. The effectiveness of specific smother crops depends upon the weed concerned; for example alfalfa is especially useful for Canadian thistle *(Cirsium)* and perennial sowthistle *(Sonchus)*.

Rotations

Although rotations are practiced for several reasons, one of their greatest values is in weed control. Many weeds are widely tolerant of growing conditions, but the large majority of them thrive best with specific crops or under specific management procedures. Successful weed species are frequently those whose life cycle is similar to that of the crop with which associated. Such weeds tend to become progressively worse each succeeding year that the particular crop is grown. Rotations break this cycle; they change the habitat beyond the tolerance of the weeds. It has been stated that out of about 1,200 species commonly called weeds on the North American continent only about 20 are able to succeed under common rotations involving a cultivated crop, a small grain, and a legume or grass sequence.

BURNING

Burning has been used in the past and is still employed to some extent as a method to destroy weeds along railroad rights-of-way. It has been used to a limited extent in certain crops. Controlled burning in permanent pastures and in certain woodland areas, especially in the South, has been said to encourage grasses and improve the quality of the pasture.

BIOLOGICAL CONTROL

Biological control of weeds involves the encouragement of certain pests or parasites of these plants, either diseases or insects. Biological control has been employed with a considerable degree of success with several insect pests. It has not usually been successful with weeds. The problems are complex, involving not only the relationship between the insect or disease which may attack the weed, but the secondary relationship between that organism and its pests or predators. Likewise, there is always the problem of what other kinds of plants might be attacked or destroyed by the disease or insect pest of the weed. Two reasonably successful examples of biological control of weeds are those of the St. Johnswort *(Hypericum)* in the western United States and the prickly pear cactus *(Opuntia)* in Australia.

The potential of biological weed control is recognized. However, many workers have hesitated to invest efforts in this area without more concrete evidence as to direct usefulness. Studies have been conducted in California, the author (C. B. Huffaker), stating in part, "... there is little justification for the negligence of ecologists to appraise the role of insects and arthropods in the composition and structure of natural vegetation, or their unilateral emphasis of factors of the environment, such as rainfall, exposure, temperature, winds and edaphic conditions, or the competitive and inhibitive complexes."

Perhaps the above viewpoint has merit. The implications are not limited to the biological control of weeds but to the field in its total aspects. We need to know more about the biological sequelae of the variables of micro-environment, and possess a more complete identification of the niches which weedy species, crop plants, and other organisms occupy in a holoceonotic whole. An improved understanding of such biological mechanisms would allow us to better envision — on a long range basis — the possibilities of maintaining desired vegetational equilibria in crop production areas.

INTERRELATIONSHIP OF WEED CONTROL METHODS

As we have emphasized before, weeds are controlled by a combination of methods, not any one to the exclusion of others. Any cropping or cultural procedure involves the mechanical methodology suitable to the crops involved as well as the competitive action of these crops. And when crop rotation is brought into the picture, one is considering the additive effect of a given sequence of such measures.

The objectives of weed control procedures include the reduction or elimination of the competitive action of undesired plants. In accomplishing these objectives, it is economically desirable to accomplish weed control simultaneously with full crop production. It is not practical to forget everything else while measures to reduce weeds are given first priority. In order that this be feasible, it is essential to take full advantage of potential flexibility in crop sequences, possible variations in production methods, and the timing of specific operations.

Some examples: A considerable time range is possible for the planting of grain sorghums. If annual weed infestations are a limiting consideration, late planting is preferable inasmuch as it allows time for one or two preplanting workings of the soil to reduce the weed seed potential in the upper soil layers. Furthermore, sorghum germinates more rapidly and possesses better competitive ability in warmer soils.

The inclusion of smother crops in a rotation sequence may favor the reduction of certain perennial weeds. But smother crops are not employed as entities in themselves; they are related to preplanting and post-harvest cultivation measures. The choice of the smother crop may have considerable significance. A tall growing annual (e.g. sudan grass) will frequently have more applicability in weakening a vigorous weed stand than the lower growing perennial, alfalfa. But the latter, if maintained in vigorous condition, may find its greatest usefulness in essentially eliminating a previously weakened infestation of, for example, Canadian thistle — owing these merits to a combination of the competitive ability of established alfalfa and the harvesting procedures, i.e. mowing, to which this crop is often subjected.

The helpfulness of timing of control action against perennial weeds with respect to root reserve levels has already been discussed.

Chemical weed control is detailed in subsequent chapters and has not been included in the above examples. But the same philosophy is applicable: that a given chemical procedure is of value primarily to the extent that it dovetails with a total operational sequence, that it is not the chemical treatment alone, but the sequence of which it is a part which will determine the value of the chemical operation.

25. Chemical Weed Control

Chemical weed killers or herbicides have been used in a limited manner for many years. Until recently, however, research progress was limited, and the total significance of herbicides in agriculture was relatively small. The discovery of the potentialities of certain growth-regulator substances (2,4-D and related compounds) as selective herbicides served to stimulate unprecedented interest in this field and triggered a new era. The last 15 years have witnessed feverish activity by industry, agricultural universities, and the United States Department of Agriculture in developing and promulgating new methods and philosophies of weed control. During this period, dozens of new chemical weed killers have appeared on the market. New ways of applying chemicals have likewise been conceived and advocated. No doubt as progress continues, the herbicides will become more and more important. However, in the following discussion it should be kept in mind that at the present time chemical weed control is usually a supplement to — not a substitute for — good cropping practices; that satisfactory control of most weeds can ordinarily be achieved through application of these practices; that chemicals are expensive, both as to purchase price and application; that the successful use of herbicides requires experience and skill; and that herbicides are capable of injuring crop plants as well as weeds.

A HISTORICAL NOTE

The use of chemical materials for killing weeds lagged considerably behind their employment as fungicides or insecticides. The introduction of the Bordeaux spray for the control of certain plant diseases during the latter part of the last century stimulated interest in the use of chemicals as pesticides. The selective action of copper salts against mustards and other broad-leaved weeds in small grains was discovered around 1900 and was followed within the next decade by similar utilization of dilute sulphuric acid, sodium nitrate, and ammonium sulphate. That there was interest in this field is indicated by a statement by Bolley in 1908, writing from North Dakota: "When the farming public has accepted selective weed controls as a method of attacking weeds as a regular farm operation, the gain of the country at large will be greater in monetary consideration than that which has been afforded by any other single piece of investigation applied to field work and agriculture."

Between 1915 and 1930, sodium chlorate and the acid arsenicals were introduced, as well as a few other chemicals of limited application. Since the advent of 2,4-D, and especially in the last ten years, many more chemicals have been tested for herbicidal properties than had been in the previous half century.

CHARACTERISTICS AND CLASSIFICATION OF HERBICIDES

Herbicides may be classified in a number of ways: as to the manner in which applied, their formulation, manner of killing, their degree of selectivity, etc. Some of these considerations are discussed below.

Selective and Non-selective Herbicides

Some substances employed as weed killers are poisonous to all vegetation. When applied at proper dosages they will provide a complete kill. Chlorates, borax compounds, and various herbicidal oils constitute examples. Other herbicides (e.g. 2,4-D) are selective in their action; they are capable of killing some kinds of plants, but will leave others relatively unharmed. Since most weed control problems involve killing weeds which grow in crops, it is obviously selective herbicides which have the greatest potential importance to agriculture.

The words selective and non-selective are frequently used as if the distinctions were black against white, i.e. qualitative in nature. This is not the case; the differences are at best quantitative. Dependent upon dosage, formulation, method and timing of application, many herbicides may exhibit either selective or non-selective action; their lethal spectrum may be variously broadened or narrowed. For example, dalapon and some of the urea compounds are employed both as selective and non-selective weed killers. 2,4-D is a selective herbicide but the number of kinds of plants which are affected is greater at higher dosages. Likewise, the action of 2,4-D depends upon manner of application; as a post-emergence treatment it does not kill grasses, but when put on the soil (pre-emergent), germinating seeds of both grasses and broad-leaved (dicotyledonous) weeds are killed.

Manner of Application

Weed killers are applied to the plant or to the soil. In the former case, they are put on as sprays, post-emergence (i.e. after the weeds are up and growing). They are absorbed into plants primarily through the leaves. Action may be nonselective, sometimes termed as general contact (Sinox or Dow General), or selective (2,4-D). When applied to the soil, the herbicide obtains access into a previously emergent plant through the root system. All portions of germinating seedlings are probably susceptible. Soil sterilants and pre-emergence treatments are administered on the soil.

Soil Sterilants

There are a great variety of chemicals which can be used as soil sterilants — the chlorates, urea compounds, boron compounds, dalapon, and TCA. Many commercial preparations consist of mixtures. If effective, they kill all vegetation, underground parts as well as tops. They often render the soil unfit for plant growth for extended periods of time.

Soil sterilants are usually employed in two types of situations: (1) on non-agricultural soil, industrial areas, around farm buildings, railroad yards and rights-of-way, etc., (2) in agricultural areas when the destruction of persistent noxious weeds takes priority over other considerations. Utilization of sterilants in this latter instance is often limited to spot-treatment on relatively small areas because of the expense of the operation and the fact that the land frequently must be temporarily withdrawn from production. However, reasonably economic short-term sterilant treatment (e.g. with dalapon) is now possible without seriously affecting land utilization. It is usually desirable that subsequent crops be ones reasonably resistant to carry-over affects of the chemical.

With the passage of time, the herbicide gradually disappears as a consequence of leaching and breakdown; the latter is probably largely due to the activity of microorganisms. The rate of dissolution of herbicides is various, and soil sterility may be relatively ephemeral or persist for several years. Expected duration is dependent upon several factors, the physical and chemical characteristics of the treatment chemical itself, the dosage, the kind of the soil to which applied, the prevalence of rainfall, and the amount of organic matter in the soil.

In the use of sterilants, it is desirable to consider the danger of injuring nearby plants. The roots of small plants may extend one to two feet laterally, but those of shrubs may cover a radius of six to ten feet. Therefore, it is easy to affect valuable plants even though the soil treatment may be several feet away. Also, subsequent rains may carry the chemical to plants some distance away.

Pre-emergence Herbicides

Pre-emergence treatments are selective in action. Application is made to the soil, usually at the time of planting, or between planting and emergence of the crop seed. Administration may be as a spray, or dry in granular formulation.

The idea behind pre-emergence treatment is to give the crop a chance to start out under essentially weed-free conditions. Given such a start, two to four weeks (or more), vigorously growing crop seedlings can usually out-compete subsequently emerging weeds. Thus, from the practical standpoint, weed control can be achieved in one operation.

The theory of pre-emergence weed control goes back several years but actual development and integration into farming procedures is almost entirely within the last decade. A high proportion of recent work in the field of weed control has been devoted to the development of pre-emergence chemicals and procedures. Many of the newer herbicides are of this type, e.g. CDAA, Alanap, simazin.

Pre-emergence application of herbicides is, at the present time, essentially limited to larger-seeded crop kinds. Major attention, in the North Central states, has been devoted to corn and soybeans. Sorghum is now receiving some consideration. Pre-emergence methodology assumes that the major weed problems in these crop kinds are caused by annuals; treatments are ineffective in perennial weed situations.

The efficacy of pre-emergence weed control is essentially based on three facts: (1) applicable herbicides will kill weed seedlings as they germinate, (2) most effective weed seed germination is from the upper 1/2 to 3/4 inch top layer of the soil — weed seeds occurring at greater depth usually remain dormant until brought to the surface by cultivation or other means — (3) large-seeded crops are planted below the zone from which most weed seedlings arise.

On this basis, therefore, the crop seeds are planted, the soil is treated with the herbicide which kills the weed seedlings in the top layer, but the crop seedlings growing from below can penetrate the treated soil without injury.

But there may be difficulties. Movement of the treatment chemical will not necessarily be restricted to the top soil layer; downward penetration can result in injury to the crop as well as weed seeds. Movement tends to be more rapid in light than in heavy soils; the use of pre-emergence herbicides in sandy soils is often hazardous. Heavy rains immediately after treatment may likewise carry the material down to the crop seeds and affect injury. On the other hand, excessively dry conditions may result in little or no movement and yield unsatisfactory weed control. Herbicides differ in their degree of solubility (hence likelihood of leaching downward), persistence in the soil, degree of toxicity to different crop and weed species.

What are the relative merits of pre-emergence versus post-emergence treatment as compared to cultivation? Successful pre-emergence treatment can serve as insurance against weather conditions preventing timely cultivation, can eliminate in-row weeds not easily accessible to later cultivations, can reduce the number of cultivations required, or at best can completely eliminate the necessity of subsequent working of the soil. On the other hand, under unfavorable conditions, pre-emergence treatment may only constitute an expensive operation without correlative yield benefits. Post-emergence treatment is not possible in soybeans with presently available chemicals;

the only opportunity to employ herbicides is before emergence. In corn, it is necessary to weigh the limitations and potential benefits of pre- or post-emergence chemical treatment in order to determine which is the preferable course of action. These topics are more fully discussed under the crops concerned.

Expense may be a major consideration in the employment of pre-emergence herbicides, although, with increasing use, prices have dropped sharply the past few years. Nevertheless, except for 2,4-D, the cost in terms of yield benefits frequently renders complete coverage uneconomic. Application then is often made in bands over the rows. The bands are usually 12 to 15 inches wide, assuming 40 inch rows.

Formulation of Herbicides

Weed killers may be purchased as dry powders, in granular form, or as liquids. They may be applied by spraying, or administered dry.

Materials which go into liquid formulation include (1) powders which form true solutions (amino triazole), (2) wettable powders which do not dissolve but are dispersed by agitation (simazin), and (3) liquid concentrates often in oil solution which must be emulsified in water in preparing the spray solution (2,4-D ester).

There are handling and application problems peculiar to each formulation type. Wettable powders tend to "settle out," require continuous agitation, and may plug up sprayer lines and nozzles. Oil concentrates likewise must be dispersed in water; most of them emulsify easily. Frequently commercial preparations contain an emulsifier to aid in stabilizing the "solution" and a wetting agent to improve spreading and penetrating qualities; sometimes an adhesive agent is also included. In some instances, oil solutions rather than water are employed as the spray formulation (2,4-D — 2,4,5-T mixtures).

Granular herbicides are of considerable current interest. These "granules"[1] consist of an inert carrier onto which the active chemical has been absorbed. They have been tested primarily for pre-emergence or pre-planting application. Approximately the same weed killing results have been achieved for weed killers in granular preparation as when spray-applied. The granules are applied to the ground; if the soil is dry, they are best worked in with a rotary hoe or weeder. Spraying problems, as above discussed, are obviated; toxicity risks to the operator (as with liquid CDAA) may be reduced.

Several of the pre-emergence chemicals are now available either in their conventional dry or liquid form, or as granules.

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[1] The word "granular" unfortunately is employed for two different kinds of preparations: those as above described, but also some of the soil sterilants which are merchandised in dry form but without an inert carrier.

Herbicidal Action

It is not within the scope of this text to treat the mechanisms (biochemical and biophysical) of herbicidal action. Brief reference is made to certain theories concerning the action of 2,4-D under the discussion of that chemical.

General factors affecting herbicidal killing include (1) penetration, (2) degree of translocation, and (3) toxic action.

Some of the selectivity exhibited by herbicides can be ascribed to differential penetration, but the importance of this phenomena is less than once believed. Plant leaves and stems possess a protective cuticle, and frequently a waxy coating, and are, in general, susceptible to non-polar molecules. On the other hand, root hairs readily take up polar substances. The use of low gallonage applications and detergents as wetting agents have to a large extent minimized the importance of leaf shape, pubescence, and extent of protective wax covering as causes of differential penetration.

The degree of translocation of herbicides is widely variable. Some appear to move within the plant only to a very limited extent. 2,4-D is translocated up and down quite readily, but less so in horizontal rhizomes or creeping roots. Amino triazole is apparently moved throughout the affected plant.

Status of Our Present Knowledge

Herbicidal weed control is only fifteen years old. During this brief period, innumerable chemicals have been tested for plant killing ability, new ways of applying chemicals have been developed; the total interrelationship between weed control and crop production has been under continuous scrutiny. A considerable array of herbicides are now available of which a high proportion have not yet been on the market five years.

All of this suggests several things: that we are in a state of flux, that we need more information about many of these chemicals, and that there is probably not yet complete agreement as to the merits of various herbicides, or methods of treatment.

One consequence of the above is that recommendations and viewpoints do not all agree. This is a natural consequence of the rapid evolutionary developments in the field. One should be aware of these facts and give them due recognition in adapting new methods in his farming practices. It is desirable to obtain as much information as possible about specific herbicides or procedures and to consider the consequences, economic and otherwise, of their employment. After reaching tentative conclusions, one might like to try herbicidal treatment on a small or experimental scale for a year or so before venturing a major farming operation.

26. Important Herbicides

The number of chemicals now commercially available and under test is very considerable. Each substance possesses a chemical designation; for example, that of 2,4-D is 2,4-dichlorophenoxyacetic acid, merchandised as either an amine salt or various ester derivatives. Chemical names provide a precise means of designating compounds and furnish a concise description of the chemical structure. However, they are too cumbersome for popular use, and a system of common names has been standardized by the Weed Society of America. In some instances, the names are alphabetic appellations derived from the chemical description, for example CDAA for 2-chloro-N, N-diallylacetamide, DNBP for 4,4-dinitro-ortho-secondary butylphenol. The origin of "2,4-D" is likewise obvious from the chemical terminology given above. The names of other herbicides (e.g. dalapon and monuron) are words which bear little relationship to their chemical characterizations.

Herbicides are usually sold under various trade and brand names. Randox is a well known proprietary designation for CDAA; DNBP and related compounds are sold as Sinox, Premerge, Dow General, etc.

Obviously, some classification of herbicides is necessary to provide a pattern for discussion and understanding. In the following treatment, a chemical grouping has, in most instances, been utilized; that is, those compounds having the same basic chemical structure are discussed together. This procedure has merit in that structurally similar substances tend to possess analagous attributes and unit generalizations can be employed. For example, the first group-heading below considers the phenoxy compounds, or growth hormone herbicides. These include 2,4-D, 2,4,5-T, and MCP, all of which have similar weed killing properties and are employed in somewhat the same manner. Insofar as possible this procedure is followed throughout the following section.

Trade names are employed to some extent in the subsequent enumeration — but with the usual non-warranty that no superiority of one manufacturer's product over another is to be implied.

The herbicidal field is an active and highly specialized area. The following treats only those herbicides most widely used or which are the subject of current interest. No doubt certain recent developments, of considerable potential significance, have been omitted.

2,4-D AND RELATED CHEMICALS

These are variously termed growth regulator or hormone type weed killers, or phenoxy compounds. Their most noteworthy characteristics as a group are (1) a high degree of selectivity with regard to different kinds of plants, and (2) the fact that the chemical can be used in relatively low dosages in comparison with many other herbicides. The phenoxy compounds are employed primarily for the control of broad-leaved weeds among tolerant grasses, and with pre-emergence application, primarily in corn, for the control of annual broad-leaved weeds and grasses.

2,4-D is an organic acid (2,4-dichlorophenoxyacetic acid). It is available in either amine or ester form. The amines are usually employed in small grains, flax, corn, and on lawns. The esters, of which several are commercially available, are liquids which are insoluble in water but are soluble in oils. They are usually formulated by dissolving in oils. For application, the concentrate is emulsified in water with the help of an emulsifying agent or, in some instances, is applied in oil. The esters are used selectively in corn, for pasture and roadside spraying, as components of brush-killers, and for pre-emergence treatment of corn.

Dosages of 2,4-D are usually given in pounds per acre of acid equivalent, regardless of the formulation employed.

2,4-D as a Post-emergence Herbicide

There are distinct differences between the post-emergence characteristics of 2,4-D esters and amines. The esters are more toxic to plants than the amines. They are somewhat volatile, but the several kinds differ in this characteristic and are sometimes designated as low- or high-volatile forms. If esters are used in proximity to susceptible ornamental plants or crops, volatility and spray drift constitute hazards. They are frequently valuable in situations in which injury to crops is not critical.

Conditions under which 2,4-D is applied modify its effectiveness. In general, propitious times are those favoring rapid growth of the plants, temperatures 70° or above, and freedom from rainfall for 24 hours after treatment. The affected plants are killed slowly. They stop growing and become distorted. The leaves become twisted, brittle, or sometimes water-soaked. Subsequently, the stems and leaves dry up and disintegrate.

Penetration by amines is slower than penetration by esters. Hence, a rain a few hours after spraying is not as likely to remove the effect of an ester as that of an amine. On the other hand, the amine can be "souped up" with a wetting agent. However, this will cut down upon its selectivity. Esters more easily penetrate certain "resistant" perennial species — leafy spurge *(Euphorbia)*, Russian knapweed *(Centaurea)*, perennial peppergrass *(Cardaria)*. In other instances, massive penetration by the esters may result in injury to vascular tissue before significant translocation to the roots can take place. The slower, less spectacular effect of the amines may thus result in a more complete kill. Also, there is some evidence that too heavy applications, resulting in premature death of the tops, may render kill of underground parts of perennial weeds as unsatisfactory as an underdose. An additional consideration after application of 2,4-D to perennial weeds is to allow time (2 to 3 weeks) before cultivation for movement of the herbicide to the underground parts.

Grasses are not readily killed by 2,4-D, while the majority of broad-leaved weeds are variously susceptible. In addition to grasses, common or important weeds which are quite resistant to 2,4-D include white campion *(Lychnis)*, milkweed *(Asclepias)*, bouncing-bet *(Saponaria)*, Russian knapweed *(Centaurea)*, tanweed *(Polygonum)*, and leafy spurge *(Euphorbia)*. Somewhat resistant weeds (several applications usually required for complete kill) include Canadian thistle *(Cirsium)*, prickly lettuce *(Lactuca)*, horsenettle *(Solanum)*, perennial sowthistle *(Sonchus)*, wild buckwheat *(Polygonum)*, and purslane *(Portulaca)*. Sensitive or easily killed weeds include butterprint *(Abutilon)*; cocklebur *(Xanthium)*, shoofly *(Hibiscus)*, kochia *(Kochia)*, ragweed *(Ambrosia)*, wild carrot *(Daucus)*, hoary vervain *(Verbena)*, whorled milkweed *(Asclepias)*, docks and sorrel *(Rumex)*, yarrow *(Achillea)*, poison ivy *(Rhus)*, mustards *(Brassica)*, annual morning-glories *(Ipomoea)*, plantains *(Plantago)*, biennial thistles *(Cirsium)*, and chickweed *(Stellaria)*.

Some dicotyledonous crops are resistant to 2,4-D and/or other phenoxy compounds to the degree that selective utilization can be made. Subject kinds include flax and, under some conditions, various of the leguminous forage crops. The herbicides must be applied in light dosages; only highly susceptible broad-leaved weeds will be affected.

The fact that 2,4-D and its congeners do not ordinarily kill grasses does not mean that serious damage to crops cannot be brought about. Corn and small grains are most apt to be affected in the seedling stage, or after the flowering head has begun to form. In the latter instance, the seed set may be affected. The "safe" periods then are between the seedling and flower-initial stages, and after the seeds are fairly well matured. Even though spraying operations are carefully timed, injury may result under certain combinations of conditions: hot weather, the plants rapidly growing, and overdosage. Such injury may be manifested in abnormal growth, root weaknesses, and stalk brittleness (favoring lodging) and general reduction of vigor.

Beyond considerations affecting the crop being sprayed, unintentional injury to other plants may be wrought. The consequences of spray drift and volatility should always be kept in mind. Soybeans are frequently adjacent to corn fields, and home gardens to lawns. Careless roadside spraying may cause havoc in adjacent fields. Considerable difficulty has been experienced in several of the southern states (e.g. Arkansas and Louisiana) in areas where both rice and cotton are produced. 2,4-D is useful for controlling broad-leaved weeds in rice, but cotton is easily killed by traces of the herbicide. These states have laws regulating the use of 2,4-D and similar herbicides.

Subsequent use of equipment for other jobs (e.g. applications of insecticides) may result in unexpected crop injury if sprayers are not carefully cleaned (methods are discussed in a following section). For home lawn applications it is best to have one knapsack sprayer reserved exclusively for the use of herbicides.

2,4-D is non-toxic to animals, but treated areas probably should not be grazed immediately after spraying. It is possible that 2,4-D could mask the flavor of unpalatable or poisonous species, or that 2,4-D injured plants may produce and accumulate abnormal chemical constituents. Thus the herbicide might indirectly contribute to stock injury.

What does 2,4-D do in order to kill? After penetration it is apparently translocated to meristematic regions. This translocation may take place readily up and down but appears limited laterally, especially in underground roots or rhizomes. The translocation is in the phloem and seems to be correlated with the movement of photosynthates.

The action of 2,4-D involves a reduction in growth and an increase in respiration, but the mechanism is not clearly understood. It has been suggested that, as a consequence of the increase in respiration, the plants simply respire themselves to death. It is probably not this simple. One recent hypothesis involves the substitution of 2,4-D in the respiratory cycle in which it catalyzes the splitting of high energy phosphate linkages. Another theory is that, acting in the leaves, it prevents synthesis and/or movements of certain proteins found in the leaves. This suggestion is attractive for it affords an explanation of the high degree of selectivity between plants, such selectivity being upon the basis of different proteins. It has also been inferred that 2,4-D interferes with the normal auxin balance.

2,4-D as a Pre-emergence Herbicide

The second major utilization of 2,4-D is for pre-emergent treatment in fields of corn. Application is made to the soil at or immediately following planting. The effect on the soil seems to be limited to a few weeks following planting.

The above generalization that the esters are more apt to cause crop injury (as compared to the amines) is reversed. With respect to pre-emergence treatment, the esters are less subject to leaching and thus, in event of rain, are less likely to be washed down to the crop seeds.

Ordinarily, as indicated by the above discussion, 2,4-D is applied by spraying in liquid solution or suspension. Relatively recently it has become available in granular form and may be applied dry for pre-emergence use or in mixtures with other substances as a sterilant.

The pre-emergence utility of 2,4-D is discussed in further detail under treatment of weed control in corn.

Herbicides Similar to 2,4-D

The above discussion has related specifically to 2,4-D, but most of the generalizations apply equally to several of the related phenoxy compounds. 2,4,5-T (2,4,5-trichlorophenoxyacetic acid) is usually employed in mixtures with 2,4-D for spraying woody plants. MCP (MCPA, 2-methyl, 4-chlorophenoxyacetic acid) is somewhat milder in toxic effect to some crops than 2,4-D and is most frequently recommended in situations where possible injury to crop plants is critical, e.g. flax, oats with a legume understory, peas, or in lawns. This "milder" action of MCP does not necessarily apply to all weeds; Minnesota has reported certain kinds more easily killed than by 2,4-D.

Two relatively new phenoxy-butyric acid derivatives, termed by the designations 4-(2,4-DB) and 4-(MCPB) tentatively "look good" in legume seedings or in established stands for seed productions. These chemicals have been tested at sufficiently high dosages to kill numerous weed kinds, and without injury to the forages. They should not be used on legumes to be grazed, or cut for hay as tolerances have not yet been set by the Food and Drug Administration.

Silvex (selective in turf) is a phenoxy-propionic acid. Sesone (SES, Crag Herbicide-1) constitutes another choice for pre-emergence use.

Erbon (Baron) also chemically falls in the 2,4-D family. It is a soil sterilant. 2,4-D itself is sometimes mixed or applied with other compounds as a double action soil sterilant, e.g. borate — 2,4-D combinations.

OTHER HERBICIDES

Dinitro Compounds

These are also known as dinitro phenols or substituted phenols and have received various designations as DN, DNOSBP, and more recently DNAP and DNBP. Sinox, Dow Selective, Dow General, and Premerge all fall into this group.

The dinitros have found utilization the past 15 years in a variety of general contact or selective roles. With the continuing advent of new kinds of weed killers, this role may be diminishing. Some pertinent (and to some extent controversial) areas of utilization in the North Central states are: (1) Corn. DNBP amine. The herbicide may be applied before or as the crop seedlings emerge, or when the young plants are six to ten inches tall; reports as to effectiveness are not in agreement. (2) Legumes. Post-emergence in seedings or (heavier dosages) on dormant alfalfa. (3) Soybeans. Pre-emergence. Satisfactory results against both grassy and broad-leaved weeds are usually obtained unless the weather is excessively dry. Bean injury sometimes results. (4) Small grains. There is less likelihood of injuring the legume understory than with 2,4-D. (5) Flax.

These compounds have some shortcomings from the handling standpoint. The cresol forms (general contact herbicides) are oily liquids and must be emulsified in water; they are poisonous and readily stain hands and clothing. The DNBP sodium and amine salts are water soluble and selective in action. Toxic action is correlated with temperature, and this fact must be kept in mind in predicating dosages if crop injury is to be avoided.

Urea Compounds

These substances are capable of playing two roles: (a) soil sterilants, and (b) at reduced dosages, selective herbicides.

As sterilants, at moderate level treatments — usually in small areas since the unit cost is relatively high — they may be employed in cropped soil where the objective is to kill persistent perennial weeds and if possible to avoid extended soil sterility. "Complete kills" are most frequently achieved with shallow-rooted weeds (e.g. quackgrass). Higher rates of treatment are used on industrial or non-agricultural ground, irrigation ditch banks, railroad right-of-ways, etc. where continued soil sterility is the specific objective.

Some of the subject chemicals are Monuron (Telvar), Diuron (Karmex), Neburon (Kloben), Fenuron (Dybar), and Urox. Dosage and nature (whether dry or in water) of application depends upon the specific weed killing objectives to be achieved, and the particular herbicide used. When water suspension application is employed, continuous agitation is necessary to prevent settling and sprayer trouble.

Soil sterilants are frequently mixed in various ways. BMM (Ureabor) for example, is a monuron-borate mixture.

The urea compounds have several potentialities as selectives. For example, recent work in Wyoming has demonstrated that Diuron (2 to 3 pounds per acre) is very effective in eliminating most annual weeds in established alfalfa. Monuron has proved successful in weed control in citrus orchards in California without injury to the trees. Both of these substances are employed selectively in several kinds of vegetable crops.

Carbamates

The carbamates include the weed killers designated as IPC and CIPC, and EPTC or Eptan.

CIPC has proved useful in such diverse areas as reducing broad-leaved weeds in legumes and barnyard grass in rice. It has been attempted for pre-emergence employment in soybeans but has not gained wide acceptance. It may have potentialities against dodder in legumes for seed production. Partial control of both grassy and many broad-leaved weeds is feasible in dormant alfalfa.

EPTC has had a short and troubled career. It was commercially available in 1958 and 1959 seasons, when it appeared to have considerable potentialities as a pre-emergence herbicide, especially in corn. However, an unexpected degree of crop injury was encountered and the manufacturer has placed it on restricted sale for the 1960 season pending further research.

Amino triazole (Amizol, Weedazol, Amitrol)

This compound, a white powder soluble in water, kills most vegetation. Readily translocated, its application results in chlorosis; lethal action is slow and new shoots may appear but they likewise are chlorotic. It has been recommended as a means of controlling perennial weeds (e.g. Canadian thistle and quackgrass), and should be applied at the rate of 8 pounds of 50 per cent preparation per acre in approximately 50 gallons of water when the plants are 6 to 10 inches high. A wetting agent may increase effectiveness. Subsequent mowing is undesirable as it may prevent translocation of the chemical to the roots. Cultivation should be delayed for 2 to 3 weeks. Since this chemical affects all plants, it can scarcely be used in crops or pastures. Early spring application in some areas may be followed by a late planted crop (the material has no carryover effect in the soil). Treatment of non-crop areas or spot applications may be made later in the summer. If a knapsack sprayer is used for the latter, 4 to 6 tablespoons of the chemical per gallon of water per square rod will provide a reasonable dosage. Hard-to-kill weeds (e.g. tanweed, *Polygonum*) may require several applications.

TCA (Trichloroacetic acid, sodium salt)

TCA has demonstrated usefulness in a variety of roles. It can be employed as a selective herbicide, about 5 pounds per acre for some forage legumes and in flax. It is sometimes recommended for the control of perennial grasses, quackgrass in the North, Johnson grass in the South. Dosages range from 1 pound per gallon per square rod for complete kill on small areas to 20 to 40 pounds per acre for stand reduction. Application may be made as heads appear or in late summer. The grass should be mowed, followed by removal of the hay and/or disking. Effectiveness is influenced by several factors, e.g. rainfall or amount of organic matter in the soil. Injury to subsequent crops may ensue if abnormally dry conditions prevail.

TCA is an unpleasant material to use. It is somewhat difficult to get into solution and is sold either as a solid (sodium salt) or ready-made solution. It is injurious to the human skin (should immediately be rinsed off) and is extremely corrosive to spray equipment.

Dalapon (Dowpon, 2, 2-dichloropropionic acid, sodium salt)

Dalapon is a translocated herbicide. In the North Central states considerable attention has perhaps been devoted to its possible usefulness in quackgrass control. For example, Wisconsin workers suggest its employment applied in the spring at 5 pounds (74 per cent acid equivalent preparation) per acre. Plowing may follow 3 to 7 days after treatment, but planting should be delayed 2 to 3 weeks or crop injury may result. Alternately, fall applications at 10 pounds per acre may be made, but control was found to be less complete. Similar Minnesota studies have related to the control of quackgrass in potato growing areas. The investigators suggest spring application of 10 pounds of dalapon per acre. They indicate that subject areas can be plowed and planted to potatoes a week to ten days after treatment without injury to the crop.

In small areas, 1/8 pound per gallon of water per square rod, fall and subsequent spring treatment, has been found to be reasonably effective. Higher dosages can be used if extended soil sterility is desired.

Dalapon has also received attention for Johnson grass control and applied at heavier rates, it can be employed as a sterilant. It has proved useful as a selective herbicide against annual grasses in seedings of alfalfa or birdsfoot trefoil at 2 to 4 pounds per acre with no companion crop. It has been recommended in low dosages (1 pound per acre) for grass seedlings in flax.

Simazin and Atrazine

Simazin is one of the newer pre-emergence herbicides for corn. It is available as an 80 per cent wettable powder, reasonably safe to handle and noncorrosive. Reference is frequently made to the difficulty of keeping the preparation in suspension and resultant sprayer clogging. These difficulties have largely been alleviated in the presently available formulation — the previous 50 per cent powder was less finely ground.

The chemical is usually applied 1 to 4 pounds an acre in 30 to 40 gallons of water. Effectiveness of treatment against both grassy and broad-leaved weed seedlings, relatively speaking, is excellent. The danger of injury to the corn is quite slight. Persistence in the soil is better than, for example, 2,4-D. Some usual limitations of pre-emergence chemical application must, however, be expected; i.e. the degree of effectiveness may be mediated by timeliness of rainfall; it is necessary to use lighter applications on sandy soils. Simazin, as compared to 2,4-D is rather expensive. Band application (1 to 2 pounds an acre in 10 to 20 gallons of water) is capable of cutting cost in about one third (to approximately $5.00 an acre).

There has been some concern as to possible carry-over action of simazin in the soil. Within the dosage ranges indicated above, the danger of deleterious effects on subsequent crops is probably limited, but the planting of so-called tolerant crops (corn) the subsequent season may be advisable. Heavier applications as a soil sterilant will be more likely to result in substantial carry-over.

Atrazine is a recently released product chemically similar to simazin. While it is still rather early to evaluate its merits on a comparative basis, it would seem to be as good as or possibly better than simazin for corn. It can be applied early post-emergence as well as pre-emergence. It is more soluble than simazin, hence will not be effective over as long a period, but with limited rainfall might yield better immediate control.

CDAA (Randox and Randox-T)

CDAA is effective against grass seedlings in corn and soybeans. Possibly it can also be used in sorghum but injury is more likely. It is not useful when dicotyledonous, broad-leaved weeds constitute the principal problem.

The chemical is merchandised as a liquid or in granular form. Application is usually made at levels of about 4 quarts commercial preparation per acre in 30 to 40 gallons of water; or if band treatment is employed, 1-1/2 quarts in 6 to 10 gallons of water.

Under ideal conditions, CDAA is extremely effective and causes a minimum of crop injury. However, it has certain limitations. It is toxic and handling precautions (i.e. rubber gloves, goggles) are necessary if the liquid formulation is employed; overdosage, or use on light or sandy soils is apt to result in crop injury; effectiveness is all too dependent upon the whim of weather; the material costs about $3.00 an acre for band application. It is perhaps most valuable in grass-infested, heavy soils.

Randox-T, a recent release, is capable of affecting both broad-leaved and grassy weeds. If present preliminary reports are borne out, its broader weed-killing scope should render it more widely useful than the older preparation.

NPA (Alanap)

Much work has gone into efforts to devise a dependable, pre-emergence chemical treatment for soybeans. As with other available herbicides, Alanap perhaps falls short of desired goals but may have especial value for this crop. The chemical is available as a liquid soluble in water or in granular form. It can be applied as complete coverage or band treatment. Economic considerations usually favor the latter. Under ideal soil and rainfall conditions, it is capable of giving the beans a weed-free start.

MH (Malic Hydrazide)

Malic hydrazide is a translocated growth inhibitor which has received attention for quackgrass and other grasses. It is not as effective as some of the above-discussed materials but can be used sparingly under trees.

Crabgrass Killers

Crabgrass is now the most conspicuous weed in home lawns in the North Central states. Several chemically unrelated herbicides are available to aid the harassed home owner or turf manager. Their action is essentially selective. The annual crabgrass and its seedlings are killed; the established perennial bluegrass is frequently yellowed but survives. Success in eliminating crabgrass through the employment of herbicides is frequently incomplete because several applications 2 to 3 years in succession are often necessary before seed resources in the soil are exhausted. Proper renovation of the bluegrass turf is necessary if reinfestation is to be prevented.

Currently recommended weed killers include PMA (phenylmercuric acetate), DSMA (di-sodium methyl arsenate), chlordane, and KOCN (potassium cyanate).

Ammate (AMS, Ammonium Sulfamate)

A non-selective killer and soil sterilant, ammate is used for poison ivy and miscellaneous perennial weeds (for example, leafy spurge) which are resistant to 2,4-D. It prevents re-sprouting on stumps and aids decomposition. It is sometimes employed as a sterilant along sidewalks, paths, and driveways. Foliage spray applications usually require 1 to 3 gallons of water per square rod (about a pound of the chemical in a gallon), thus it is obviously too expensive to use in large areas. The material is corrosive to equipment.

Sodium Chlorate

The chlorates are non-selective herbicides and soil sterilants. They have been used for weed control purposes for 30 to 40 years.

Dry or foliage application may be employed (2 to 4 pounds per square rod). All vegetation is killed, and the soil is rendered sterile for several months. While expense prohibits use over large areas, the chlorates have been valuable weed killers for eradicating small patches of perennial noxious weeds. They are sometimes applied jointly with borax compounds, e.g. polyborchlorate.

The chlorates are strong oxidizing agents and may be flammable or explosive under certain conditions. Do not let solution get on clothing and dry! Atlacide contains additives which decrease this hazard.

Borax Compounds

Borax compounds (e.g. Borascu) are soil sterilants. They are frequently merchandised in combination with other herbicides: polybor chlorate with sodium chlorate; BMM and Ureabor with monuron; DB granular with 2,4-D; Benzabor with TBA.

Application is usually in non-agricultural soil, especially in industrial areas, railroad yards, lumber yards, and oil installations. Persistent, perennial weeds in crop soil can be effectively destroyed. Total elimination of all vegetation and soil sterility must be assumed.

Some preparations are applied dry, often available in granular form, and others are put on by spraying. They are relatively cheap but must be used in large amounts.

Benzoic Acid Derivatives

Two recently released soil sterilants are designated TBA and PBA. They have given very satisfactory control of bindweed without long term soil sterility. They do not possess corrosive or poisonous attributes of some of the other sterilants.

Arsenic Trioxide

The very poisonous, arsenical compounds were once used in a variety of ways as herbicides. They have largely been replaced by safer (less toxic to animals) and more satisfactory herbicides. However, arsenic trioxide is still employed as a soil sterilant and is perhaps the most satisfactory compound available where long term sterilization is desired. Tests in California have indicated that the effect on the soil may last up to 10 years. Frequently arsenicals are mixed with other herbicides which have a stronger initial toxicity in order to kill existing vegetation more rapidly.

Oils

A great variety of oils have been employed as herbicides, principally in two ways: (1) as complete, contact killers for above-ground weed growth along railroad right-of-ways and similar areas, e.g. kerosene, used crankcase oil, fuel oil, or diesel oil; (2) as selective herbicides in crops of the carrot family. Carrots and relatives are reasonably immune to specific grades of oils, while most annual weeds are not. The crops involved include carrots, parsnips, parsley, caraway, and dill.

27. Application of Herbicides, Spraying Equipment, Safety Problems and Laws

Farm sprayers are of many kinds. Various types are commercially available. In addition, numerous kinds of homemade units, put together through separate purchase and assembly of components, fill the spraying needs of many farmers.

Any technical consideration of sprayers is outside the scope of this treatment. The following is concerned primarily with the identification of the various parts and some considerations relating to their utilization.

Sprayers may be tractor, truck, or trailer mounted. In general, tractor mounting is the cheapest, but time is required to mount and dismount. The result is that the tractor is tied up for a couple of weeks or weeds do not get sprayed at the right time. Contrariwise, a trailer-mounted rig, although more expensive, is more adaptable to the exigencies of farm work.

Most weed spraying is done at low pressures, less than 50 pounds per square inch. Hydraulic sprayers in which the liquid herbicide is placed under pressure by a pump are employed. The spray material is forced through nozzles which disperse it into a mist and direct it in a given pattern to the subject to be sprayed.

The following are the essential components of any spray unit:

Power plant — A self-contained gasoline engine or power take-off.

Supply tank — Often an ordinary 55 gallon drum. These rapidly corrode and rust may clog nozzles. Specially treated or aluminum tanks are much less susceptible to corrosion but are more expensive. Some people use a cheap tank and replace it every year. Large units may possess tanks capable of holding one to four hundred gallons.

Agitator — Often desirable for wettable powders or unstable emulsions. Agitators are of several types depending on the nature of the pump. Most operators provide agitation by running the mixture through the bypass.

Intake filter screen — A strainer will prevent debris from the tank clogging up the pump distribution system and nozzles.

Pump — Several kinds are employed. These are basically of two types, reciprocating (piston and plunger), and those whose action is rotary (gear and roller impeller). General purpose sprayers capable of use at high or low pressures usually have plunger or piston pumps.

Since most weed spraying is done at low pressures the less complex rotary types are well adapted to low-volume, low-pressure units.

Cut-off valves — To control release of spray solution to nozzles.

Pressure regulator and gauge — To allow control of spray pressure.

Bypass valve and line — Controls pressure going to the boom.

Boom and "guns" — To distribute spray to the crop. The hand gun is manually operated. A hose connects the nozzle-containing unit to the pump line. Booms of various lengths are available but a 6-row, 21-foot type is common. The nozzles are distributed along the boom. Drop extensions are sometimes used; if these possess two nozzles at the extremity, they can then handle two rows. The boom should be adjustable in height for different jobs. It should be high enough so that the spray from adjacent nozzles will meet at the top of the weeds.

Nozzles — To distribute the spray. Nozzles are widely variable to meet the specifications of different application jobs. They differ as to angle of release of the spray, the type of pattern, and the rate of discharge. A frequently employed type possesses a 65^{0} spray fan. Broad jet nozzles are for roadside spraying or brush control and eliminate the need for a boom but give poor distribution patterns.

In addition to powered farm sprayers, knapsack applicators are desirable for spot application on small patches of weeds, and are employed by the homeowner. These units, usually of about 5 gallons capacity, operate through compression of air. After the herbicide solution is placed in the tank, the sprayer is manually pumped up. Attached straps allow the tank to be slung over the back or one shoulder. A short hose and extension tube allow gun-type spraying.

Airplane application of herbicides is practiced in some crops, particularly wheat and rice. Spraying is done on a custom basis by established companies specializing in this type of work. Gallonages as low as 1-1/2 per acre may be employed. Spray drift, if susceptible crops are adjacent, is a hazard. Injury to cotton as a consequence of rice spraying has resulted in major controversies in the southern states.

KEEP SPRAYERS CLEAN

Many of the chemicals used as herbicides (and likewise insecticides and fungicides) are corrosive. Wettable powders are frequently abrasive, shorten the life of all parts, especially gear pumps, and may stop up valves, booms, and nozzles. Thorough cleaning and rinsing is a necessity.

After each sprayer use, several rinses of water should be run through all parts. It is usually well (essential if wettable powders have been employed) to pull nozzles and strainer apart and wash them in kerosene.

Multi-purpose sprayers must be subjected to even more rigid sanitation measures. If an insecticide is placed in an uncleaned sprayer which has just been used for 2,4-D and then applied to a sensitive crop, disastrous results may ensue. Ammonia solution, a quart per 10 to 15 gallons of water can be employed for removing 2,4-D from spray equipment. After rinsing, a fresh batch should be subsequently prepared and allowed to remain in the sprayer over night. Several final rinses with water should complete the job.

At the end of the use season, subsequent to the usual cleaning, it is desirable to refill the tank and add a few gallons of used crankcase oil. A protective coat of oil will remain on all internal parts after the mixture is pumped out, and will reduce the danger of over-winter corrosion. (Be sure no water is left in any of the parts.)

APPLICATION OF THE CORRECT AMOUNT OF CHEMICAL

To achieve correct field dosage, it is necessary to determine the amount of water to which it must be added in order to achieve the desired dosage. Sprayer operation must then be calibrated to ensure that the correct amount of chemical is applied.

Dosages are usually given in terms of number of pounds per acre of the pure chemical or the acid equivalent as in the case of 2,4-D. Commercial preparations are often in the form of a liquid formulation in which the active ingredients may constitute only a part of the whole;

Amount of 2,4-D To Apply Per Acre[1]

If you wish to apply this many pounds per acre	Your chemical contains this much 2,4-D acid equivalent or MCP acid equivalent or 2,4,5-T acid equivalent per gallon						
	2.00	2.64 or 2.68	3.00	3.34 or 3.40	4.00	6.00	6.40
	Apply this amount on each acre						
1/8	1/2 pt.	3/8 pt.	1/3 pt.	3/10 pt.	1/4 pt.	1/6 pt.	3/20 pt.
1/4	1 pt.	3/4 pt.	2/3 pt.	3/5 pt.	1/2 pt.	1/3 pt.	3/10 pt.
1/3	1 1/3 pt.	1 pt.	8/9 pt.	7/9 pt.	2/3 pt.	4/9 pt.	4/10 pt.
1/2	1 qt.	3/4 qt.	2/3 qt.	1 1/5 pt.	1 pt.	2/3 pt.	3/5 pt.
3/4	1 1/2 qt.	1 1/7 qt.	1 qt.	9/10 qt.	1 1/2 pt.	1 pt.	9/10 pt.
1	2 qt.	1 1/2 qt.	1 1/3 qt.	1 1/5 qt.	1 qt.	2/3 qt.	3/5 qt.
2	1 gal.	3 qt.	2 2/3 qt.	2 2/5 qt.	2 qt.	1 1/3 qt.	1 1/4 qt.

Amount of Chemical Needed on 1 Square Rod When Treating Patches

Pounds of acid equivalent used per acre	Chemical required on a square rod[2] 2,4-D, MCP or 2,4,5-T	
	Contains 4 lb. per gal.	Contains 3 lb. per gal.
1/2	2/3 teaspoonful	7/8 teaspoonful
3/4	1 teaspoonful	1 1/3 teaspoonsful
1	1 1/6 teaspoonsful	1 3/4 teaspoonsful
1 1/2	2 teaspoonsful	2 2/3 teaspoonsful
2	2 1/5 teaspoonsful	3 1/2 teaspoonsful

[1] Adapted from South Dakota Circular 122.
[2] A square rod is 16 1/2 x 16 1/2 feet.

if sold as a dry powder, they may contain additives. For example, 2,4-D merchandized as a liquid concentrate is usually available by the gallon; this amount of volume measure may contain from 2 to 6.4 pounds (4 pound formulations are most frequently employed) acid equivalent of 2,4-D depending upon the product. It is then necessary to translate liquid measures to the desired rate of application in pounds of 2,4-D per acre. For example, if 1 pound of 2,4-D acid equivalent per acre is to be applied and a 2.0 pound per gallon formulation is at hand, it is obvious that 2 quarts would be required. Similar calculations can be made for any other dosage or formulation. For convenience, those for 2,4-D and related chemicals are summarized in the tables.

In order to assure correct rate of application, it is necessary to know the sprayer output per rod or per acre. For knapsack sprayer operation, this is often estimated, and one primarily attempts to wet down the plants to be treated. For greater precision, it is possible to stake out a square rod. Starting with a full tank of water, the operator should then spray the area with the degree of thoroughness — trying for complete coverage of the weeds in the area — that he will employ when putting on the herbicide. After completion, the amount of water used can then be determined by the amount required to refill the tank. From this, the amount of chemical to be added can be calculated. For example, if a pound of commercial preparation per square rod is to be applied and a gallon of water has been used in spraying this area, the formulation should be one pound per gallon. If the tank holds five gallons, then five pounds of chemical should go into it.

For large scale field applications, the above factors are again involved, but somewhat more precise calibration may be desirable. There are several ways this can be done, and anyone by doing a little figuring can devise what suits him best. The following procedure is merely one which appeals to the writer as a relatively simple way of accomplishing this objective: Measure off a linear eighth mile (220 yards or 660 feet). Fill the tank and make a trial run for this distance, using speed and pressure intended for operation. Measure the amount of water required to refill the tank. Multiply this figure in gallons by 66 and divide by the width of the spray swath in feet. This gives the number of gallons applied per acre.

The above calculations are based on the fact that an acre is an area 66 x 660 feet (1 x 10 surveyor's chains). If a sprayer puts down a swath 22 feet wide, the operator has actually sprayed 1/3 of an acre in traveling 660 feet. If he used 2 gallons of water, the sprayer obviously is operating at the rate of 6 gallons per acre (2 x 3: equivalent to 2 x 66/22). The chemical can then be added to the water on the basis of the number of acres to be sprayed.

The above procedure should probably be repeated several times during the season as the performance of the machinery may change with use; output of nozzles can be altered. Obviously, if nozzles are removed and new ones put on, or any other changes made in the equipment, recalibration will be necessary.

Calibrating jars are commercially available. Attached to the spray unit, the output of one of the nozzles is discharged into the bottle while the operating sprayer is driven a specific distance, usually 330 feet. Scorings on the jar make it possible, with due allowance for distance between nozzles, to read off rate of application per acre.

There may be added considerations. Changes in tractor speed will obviously affect spray coverage. A uniform pace is usually not difficult to achieve on level ground, but less so if the field has ups and downs. Band application requires determination of the proportion that the band width is of the whole. Or contrariwise, band application can be made in the trial run and the figures used directly. The same applies to late herbicidal treatment of corn in which two rates, in and between the rows are employed. Rate of application can be determined either by a working trial duplicating field procedure, or nozzle output at given speeds can be determined separately, and the contribution of each to the total job summed.

Possible overlapping of spray swaths should not be overlooked. Undesirable double spraying is all too easy to do, particularly when changing course or reversing direction. If spraying is in crop plants, double dosages may wreak damage. Contrary to the above, a very slight overlapping is desirable since nozzle patterns tend to thin out at the edge.

PERSONAL SAFETY RECOMMENDATIONS

The following are summarized from previously published safety recommendations and apply to fungicides and insecticides as well.

Storage

Store in original labeled containers (don't give a portion to someone else in an unlabeled container) in an area never used for food or medicine or animal feeds. Keep out of the reach of children.

Use

Read and follow precautions concerning safe use on the label. Herbicides should not be used in manners not recommended on the label. See if there are instructions telling what to do in case of an accident. In mixing do not allow material to slop or blow on operator. Mix only what is needed for immediate use; don't leave any excess for next application in an unmarked container. Avoid breathing dust or spray; especially watch direction of wind and stay out of mist from the sprayer. Use a mask, goggles, or rubber gloves when recommended. This especially is desirable if Randox, Dowpon, TCA, or certain of the dinitros are used. If material gets on hands or clothing it is usually best to wash and change clothes immediately. Wash clothing each day after use. Do not smoke while using chlorates or until clothing is changed afterwards.

HERBICIDE RESIDUES ON FORAGE AND FOODS

Herbicides which may be applied to the foliage of forage plants are in general non-poisonous or have a very low toxicity level (the dinitros would constitute an exception). Nevertheless it is usually unwise to spray plant materials cut for hay or silage with contact herbicides. This does not eliminate the use of selective herbicides in seedings or on mature plants in seed fields. Animals should not be allowed to graze in pastures for a week or two following spraying with 2,4-D.

The possible dangers of herbicide residues on human food were somewhat dramatically brought to public attention in 1959 by the Food and Drug Administration in connection with seizures of cranberries believed to carry traces of amino triazole. This action was taken in compliance with a Federal law (see following section) which renders food products moving in interstate commerce liable to seizure if herbicide, insecticide, or fungicide residues are in excess of certain tolerances, or if no tolerance has yet been established.

A recent Minnesota weed bulletin specifically warns that the problems relating to residues on agricultural commodities have not been investigated at this experiment station. Likewise, the subject has apparently been little studied at other experiment stations.

Plant parts intended for human consumption should never be exposed to weed sprays. This precaution does not eliminate the possibility that translocated herbicide residues from earlier soil or foliage treatments may move to subsequently developed plant tissues or parts, and therein exceed allowable government tolerances.

LAWS RELATING TO HERBICIDES

Earlier in this book, seed laws and weed laws as they relate to weed distribution and control were briefly reviewed. The Federal government and various states also have enactments pertaining to herbicides. Reference has been made to legislation in southern states which places certain restraints upon the use of 2,4-D.

The Federal laws relate primarily to human safety from injurious chemicals as noted in the above section and to proper labeling of herbicides. Two Federal agencies have such enactments. The U.S. Department of Health, Education, and Welfare is responsible for the Food, Drug, and Cosmetic Act which, in the event residues on foods or feeds are involved, sets allowable tolerances. A very considerable amount of research information concerning possible toxicity to mammals is necessary before tolerance determinations can be made. A recent amendment to this act concerning possible long range carcinogenetic effects of pesticide chemicals further renders development research lengthy and expensive.

The second law concerned is the Insecticide, Fungicide, and Rodenticide Act which is administered by the Plant Pest Control Division of the U.S. Department of Agriculture. Herbicides (and other pesticides) which are distributed in interstate commerce must be registered with this division. Registration requires adequate information on safety and performance, i.e. prior clearance by the Food, Drug, and Cosmetic Act. The law also requires specific label information on herbicide containers exposed for sale.

These laws are desirable from the standpoint of public information and safety. Unfortunately, they complicate the development of pesticide chemicals. Many substances possessing potential herbicidal properties may likewise be harmful to human beings and must be dropped from consideration.

SOME GENERALIZATIONS

With the employment of proper judgement, herbicides can increase the efficiency of farming operations and broaden profit margins. On the other hand, improper or ill-timed application of chemical weed killers may net only loss of money or time.

The individual lacking equipment or experience can frequently hire custom operators to do the work for him. If he desires to undertake it himself, he may desire to obtain suggestions as to the best material and methods to use for his particular situation. He can usually obtain advice from his dealer, or he can contact his county extension director, or the weed specialist at the agricultural college in his state. Bulletins or pamphlets, if available, are useful for reference. Directions and precautions on the containers should be read carefully.

It is often recommended that a beginning operator experiment with herbicides on relatively limited areas before he attempts a large scale operation. In this way he can judge for himself the effect of the chemical under his conditions of application and can gain some familiarity with his equipment.

28. Weed Control by Crop Kinds: Corn and Soybeans

CORN

Proper rotation, good seed bed preparation, fertilization, and cultivation until "lay-by" are basic in reducing weed populations. If properly carried out, they will, in most instances, keep weed infestations at moderate levels. Plowing should be followed by two or more diskings or harrowings, planting immediately following the last harrowing. Early post-planting cultivations are carried out with the spike-tooth harrow, weeder, or rotary hoe. These are effective only against small weeds; the harrow can be used until the corn is about 2 inches high, the weeder and hoe until it is 4 to 6 inches. Shovel cultivation should follow; maximum effectiveness ensues if the weeds between the rows are destroyed and those in the rows covered. Ordinarily no more than three cultivations are necessary; under favorable circumstances it may be possible to reduce the number to two.

Successful early cultivation will usually allow a field to go into "lay-by" in relatively clean condition. On the other hand, if necessary cultivations are skipped or carelessly conducted, serious weed problems may later ensue.

Chemical Control

The following discussion relates to the control of annual weeds, the usual kinds infesting corn in abundance. Perennial weeds, if present, may be stunted or injured by herbicidal treatments employed, but will not be killed. Special problems relating to infestations of major perennial weeds are discussed separately in a following chapter.

Generalized recommendations are not possible. Success with various herbicides and methods of procedure varies from region to region and within a specific state or farming region. The usefulness of a given treatment will depend upon the nature of the weed problem, the success of cultural control, and the weather. The employment of herbicides in corn has greatly increased the last five years because they have been progressively improved and are becoming cheaper.

Pre-emergence Treatment

There are several materials to choose from: 2,4-D, CDAA, simazin, Atrazine, and the dinitros. Application is usually made by spraying, but granular formulations are now available. Over-all coverage or band treatment may be made.

2,4-D, ester form, 1 to 2 pounds per acre in approximately 15 gallons of water is frequently employed. Seedlings of certain species of both grasses and broad-leaved weeds in the upper soil layers will be killed. Corn is ordinarily planted at a depth slightly below the affected portion of the soil. Thus it is possible to get the crop off to a weed-free start, eliminating the need for initial cultivations. In some cases, fields may be essentially weed-free for as much as four weeks.

The possibility of heavy rain immediately following pre-emergence treatment with 2,4-D constitutes a hazard in its use. Water may leach out part of the chemical and reduce effectiveness of treatment or, more important, wash it down to the corn seeds, resulting in stand reduction. 2,4-D moves more easily in light than in heavy soils; dosage is usually reduced in the former, and treatment is not advisable on sandy soils. On the other hand, if the soil is very dry and there is no rain at all, effect on the weeds may be negligible. The esters are fixed by the soils to a greater extent than amines, making them safer to use, and are, therefore, recommended.

Suggested dosages for CDAA are for complete coverage 4 quarts in 20 or more gallons of water; for band treatment 1-1/2 quarts in 6 gallons of water. Excellent control of grass seedlings is usually achieved. CDAA is most effective on heavier soils. The newer Randox-T is toxic to broad-leaved as well as grassy seedlings.

Simazin: 3 pounds per acre in 30 or more gallons of water, or in bands, 1 pound in 10 to 15 gallons of water, perhaps less in light soils, higher rates in high organic content soils. Simazin is effective against most annual weeds and tends to be more persistent in the soil than the above herbicides; hence may maintain weed free conditions for a longer period. It seems to be non-injurious to corn, but it is probably best not to follow with a legume the next year. Small-seeded legumes are sensitive to simazin and the possible consequences of soil carry-over are not yet completely known.

Atrazine is similar to simazin. As well as having pre-emergence utility, it may be employed early post-emergence. Atrazine is slightly more soluble than simazin and less persistent in the soil. It has been tailored for drier soils where low rainfall subsequent to planting may be expected, whereas simazin is best in higher moisture areas.

Post-emergence Treatment

Early season post-emergence application may be carried out when corn is 6 to 12 inches tall. If more than 12 inches high, drop extensions should be used to reduce amount of spray hitting the corn. 2,4-D is used almost exclusively, 1/4 pound ester or 1/2 pound amine per acre. Spraying is feasible also at or after "lay-by" (drop extensions; high clearance equipment), and may be recommended if late-season broad-leaved weeds become a serious problem after cessation of cultivation. Somewhat heavier dosages are usually employed than for earlier applications. Some workers have suggested a double dosage procedure, 2,4-D amine as a directed spray from drop extensions: 1/2 pound on weeds in the rows and 1 1/2 pounds per acre between rows; nozzles may be arranged so that both dosages can be applied simultaneously. The idea is to get the broad-leaved weeds in the row and to achieve pre-emergence control of both grassy and broad-leaved kinds between rows.

2,4-D is capable of injuring the corn. It will cause brittleness which can result in lodging and breakage if the field is exposed to strong wind. Corn is most likely to be injured by herbicidal treatment during hot weather when it is growing rapidly. Various hybrids differ in degree of susceptibility. Spraying should be completely avoided any time from tasseling until the silks are brown.

Pre-emergence or Post-emergence

In comparing the above-discussed methods, it may be noted that pre-emergence application serves as insurance against later weed infestations (particularly if rain interferes with subsequent cultivations), may be effective against both grasses and broad-leaved weeds, and will not cause brittleness or reduce seed set. In event of rain immediately following treatment, stand reductions may ensue with some herbicides. On the other hand, post-emergence treatment is often employed when weeds have gotten out of hand and is primarily effective against dicotyledonous kinds.

Some Economics

The above has considered herbicidal treatment of corn with respect to methods and effectiveness of treatment. Obviously the cost of treatment as compared to benefits derived must be given due cognizance if a method is to be recommended.

The principal weeds causing yield reductions in corn are annuals, both grasses and dicotyledonous kinds. Conventional cultivation methods and good fertilization are capable of reducing weeds to moderate levels which, research indicates, reduce yields 6 to 8 bushels per acre as compared to weed-free conditions. Such losses may be as high as 20 to 30 bushels under low fertility conditions. On the other hand, at least half of the time, weather conditions will be suitably favorable for timing of cultivations so that losses will be appreciably less than 8 bushels.

Figuring 8 bushels as roughly equivalent to $10.00, the cost of post-emergence spraying must be weighed against the possible yield benefits; the possibility of wind damage as a result of lodging must also be considered.

Considering pre-emergence treatment with 2,4-D, the cost is approximately $1.20 per acre if one cultivation is saved (and subtracting its cost). If more than one cultivation can be eliminated, the expense will be further reduced. Yield benefits may range from meager levels to perhaps 8 bushels per acre. Other herbicides are considerably more expensive than 2,4-D (Randox $10 per acre blanket, $3 band; simazin $15 blanket, $5 band). Herein, economics will usually dictate band application and subsequent cultivation of weedy middles. Even so, successful elimination of in-row weeds, inaccessible to ordinary cultivation, and the reduction of corn root injury by close-to-the-row cultivation constitutes no small assist to the vigor of the crop plants.

The good farmer may be the one who is most apt to be interested in the use of herbicides in corn, but he is often the one who stands to gain least. Extensive weed infestations, against which application of herbicides is clearly profitable, are usually the results of poor cultivation and low nitrogen. Herbicides will improve yield but so will fertilization and cultivation.

The value of "after lay-by" spraying perhaps deserves separate consideration. It is sometimes stated that the weeds have already done their damage, or that the corn is way above them so why worry. To some extent this is true, but competition for water and mineral nutrients during the critical seed-ripening period can certainly not improve total yield. There is also the consideration of re-infestation. If numerous late season annuals are allowed to go to seed, a ready-made weed problem will be awaiting the next season. From this standpoint, if a significant number of weeds (e.g. more than one per 3 feet of row) such as cocklebur or butterprint have escaped cultivation, late season spraying with 2,4-D may be worth the trouble. This, of course, is not true if most of the weeds are grasses; it is too late to do anything about them.

SOYBEANS

Weeds are a major factor limiting efficient soybean production. This is the viewpoint expressed by Iowa farmers in a survey of grower's opinions. Weeds received first vote among major production problems. They were designated nearly four times as frequently as either soil fertility or weather conditions.

The principal weeds in soybeans are annuals. Grasses, smartweeds *(Polygonum)*, butterprint *(Abutilon)*, and pigweeds *(Amaranthus)* are common types. It is not possible to use a post-emergence herbicide to control annual weeds as in corn.

Rotation, good seed bed preparation, not planting too early (when the soil is cold and beans emerge slowly), the choice of a variety adapted to the region and soil type, the employment of vigorous seed to give a full stand, and early season cultivation constitute basic tools for weed control in soybeans. In corn, high soil fertility reduces the weed problem; but, in soybeans recent Iowa work has demonstrated greater losses due to weeds under high nitrogen conditions than the contrary.

Timely rotary hoeing is perhaps to be emphasized as the single most important contribution to effective weed control in soybeans. This operation should be repeated 1 to 3 times as the weed seedlings emerge. If the beans are not solid-planted, 1 to 2 subsequent shovel cultivations will also be desirable.

With specific reference to the above observations, investigations in Iowa and Missouri have demonstrated yield increases of 4 to 10 bushels an acre when beans were rotary hoed. Timely versus untimely hoeing gave advantages up to 5 bushels in favor of the former. These data suggest, it is true, the desirability of catching the weeds at the right stage, but also that even inefficient use of the rotary hoe may be considerably better than none at all. Calculating beans at $2.00 a bushel, and the hoeing operations at $0.80 each ($2.40 per acre), this procedure would seem to be thoroughly worth-while.

Soybeans are good competitors once well established. If reasonable success is obtained in early season cultivation, the beans can usually proceed to maturity without a serious late season weed problem developing.

Why then are weeds to be considered a major problem in soybeans? There are probably several reasons. Not all growers employ the rotary hoe. Many may not use it to maximum efficiency either as to timing or speed of operation, and do not repeat the operation as necessary. Early planting, weather and soil conditions may grossly interfere with both bean stand establishment and hoeing. There are times of the year when a farmer may be too busy to get everything done at exactly the right time. And lastly, 2,4-D is not available as a post-emergence herbicide to rescue a weed infested field.

Pre-emergence chemical treatments frequently have application in solving some of these problems. Several herbicides are available, e.g. CDAA, DNBP, and Alanap. Alanap and CDAA are most frequently recommended in the North Central states. Alanap affects both grasses and most common broad-leaved weeds (not smartweeds, *Polygonum*). It is applied at the rate of 4 pounds per acre; this is about 3 quarts commercial preparation in band application. Dosages should be lower in sandy soils, possibly slightly higher in heavy mucks. Bean injury is a hazard. Randox is most valuable in areas with heavy annual grass infestations. The usual application rate is 4 pounds per acre, about 1-1/4 quarts of the formulated liquid for 14 inch bands. Soybean injury reports are minimal. Both of the above chemicals are likewise available in granular form.

What does pre-emergence treatment cost in terms of increased yields? Most published data (1957-1958 growing seasons) demonstrate yield increases sufficient to justify the chemical treatments. But proportionately greater benefits, in terms of operational expenses, were derived through timely use of the rotary hoe. However, in the meantime, the price of applicable herbicides has dropped. For example, figures obtained from certain Iowa experiments carried out in 1957 were based on CDAA, 14 inch bands at $4.75 an acre. As of the present time, the cost of this chemical is nearer $3.00. The expense margin in favor of the mechanical procedure (hoeing) has been considerably narrowed. Considering the tempo and direction of present developments, it is possible, in a few years, that herbicidal treatment will constitute an integral and essential phase of profitable soybean production.

29. Weed Control by Crop Kinds: Other Field Crops, Turf, and Gardens

SMALL GRAINS

The majority of weeds in small grains are early maturing annuals or winter annuals whose life cycles are adapted to that of the grain. In the North Central states most of them are broad-leaved weeds, mustards being especially notorious. Wild oats becomes a major pest in the northwest. Common perennials include quackgrass, Canadian thistle, and milkweed.

Since cultivation is not possible as in corn and soybeans, seed bed preparation, clean and vigorously growing seed, and the use of proper rotations are especially important. Rotations are the general rule in corn belt agriculture, less so in western hard wheat production.

2,4-D is of maximum usefulness in small grains without legumes. If application is made properly, chances of injury to the crop are small; many of the common weeds are highly susceptible, and the operation is reasonably economical. 2,4-D is frequently employed in oats when weeds threaten, and extensively so in wheat. Either the amine or ester formulations (1/2 pound or 1/4 pound per acre respectively) or MCP may be applied, usually when plants are 6 to 8 inches high. Small grains are quite susceptible to injury up to the 5 to 6 leaf stage, and again from when in boot until the seeds have well formed. Spraying at these times should be avoided.

Work with both wheat and oats has emphasized the fact that early weed competition (probably through reducing tillering) is much more important in reducing yield than subsequent weed growth. This suggests that if spraying is to be done, it is essential that application be made as promptly as possible after the seedling-susceptible period of the crop has passed. Application at a later date may clean up the field but have little effect upon yield.

The fact that oats are frequently employed as a nurse crop for legumes introduces a complication into the problem of weed control. It is often advisable to work the soil subsequent to grain harvest to prevent growth and seed production by numerous late summer annual weeds. If a legume seeding is present, it may be necessary to decide whether prior consideration shall be given to the legumes or to the weed problem. If 2,4-D is applied to the grain, it is capable of killing the underseeding as well as the weeds. Red clover usually has a better chance of surviving than alfalfa. In general, the herbicide probably should not be used unless the weed problem is quite serious. Injury to the legumes may be reduced by using dinitros or MCP, reducing dosages to the minimum, directing the spray up, and permitting the grain to grow as tall as possible before treatment. These measures may reduce effectiveness of weed control.

SORGHUM

Herein we are considering row-planted grain sorghums, in distinction to the forage types and the related sudan grass. The following observations are, to a large extent, derived from work conducted in Kansas.

Mature sorghum is an excellent competitor, but young plants or seedlings (especially of the grain types) are not. Pre-emergence treatment is still in the developmental stage. Significant weed infestations may, therefore, ensue in young stands. Such infestations may materially reduce yield.

Cultural and mechanical methods possess a pre-eminent importance in sorghum weed control. The relative success of such control would seem to hinge, in large part, upon the degree to which it is possible to reduce weed seed populations in the soil. Assuming crop rotation, efforts should be devoted in previous year's crops to prevent seed maturation by annual weeds. Prior to planting the sorghum, repeated seedbed cultivation is capable of destroying successive crops of weeds. Kansas urges late planting for two reasons. Sorghum is a warm weather plant; it germinates and grows much more rapidly at higher temperatures. Secondly, early planting does not allow sufficient time for adequate preplanting measures.

Cultivation subsequent to emergence is likewise to be emphasized. Specific methods employed will depend to some extent upon the procedure by which the sorghum was seeded. The rotary hoe may be used for the first working, but stand injury is often more significant than in corn or soybeans.

As earlier stated, pre-emergence herbicidal treatment is questionable. Post-emergence utilization of 2,4-D can be employed if earlier cultivations have proved inadequate. Suggested dosages and hazards are approximately the same as in corn. Formation of the head within the leaf boot begins when the plant reaches a height of about 12 inches; plants should not be sprayed from this time until the seeds have reached essentially full size.

FLAX

Flax is a poor weed competitor. It is especially important that the land used be as free of weed seeds as possible and that clean seed be employed. 2,4-D, MCP, or dinitros can be employed much in the same manner as in the small grains, but the tolerance range of flax to these herbicides is rather narrow and dosages must be watched carefully. 2,4-D is the most effective but also most apt to injure the crop. It is usually applied when the plants are 5 to 6 inches tall, 1/8 to 1/4 pound amine per acre. Flax is very sensitive to injury on coming up, but gradually develops more resistance as it gets older. However, seed set and germination may be reduced by spraying during flowering. Susceptibility varies considerably between varieties.

Flax has a slightly wider range of resistance to selective dinitros than to 2,4-D, and these compounds are sometimes used in lieu of the latter. However, avoidance of crop injury is rendered difficult by the fact that toxicity of the dinitros increases with temperature. Dalapon, 1 pound per acre, applied when the weeds are small, can be employed against certain grasses (especially *Setaria*). This herbicide can also be used in conjunction with 2,4-D or MCP.

ROTATION MEADOWS AND HAYFIELDS

This crop classification includes a wide variety of forage legumes and grasses. Plantings may involve a legume (with or without a companion crop), a legume-grass mixture, or grasses only. Weed kinds infesting these crop are likewise diverse and to some extent correlate with the crop species dominating the stand. Annuals are frequently conspicuous the first year; if stand establishment is successful and well managed, perennials may be the major weeds which succeed in persisting.

Legume seedlings are small, relatively slow-growing plants, and offer but poor competition to weeds. The cultural aspects of weed control are basic, if stand establishment is to be successful. A row crop or after-harvest tillage the previous season is highly desirable, as is seed bed preparation involving several workings of the soil. Legumes are usually seeded at rates several times exceeding the number of plants which will eventually be needed. One of the reasons for adhering to this practice is to obtain a sufficient number of vigorous seedlings to offer competition with weeds.

Several kinds of legumes are usually planted with a small grain companion crop. With respect to weed control, the grains, of course, hold back the legumes to some extent as well as the weeds. However, the early season development of seedling legumes is in any event slow and subsequent to harvest of the grain, may distinctly benefit from the prior suppression of weeds. Proper fertilization and liming (if necessary) will obviously improve the competitive relationship of the crop. Subsequent summer management practices (both first and succeeding years), insect and disease control, and mowing all aid in keeping the stand in a healthy condition.

Because of the sensitivity of small-seeded legumes to most herbicides, the usefulness of chemical control has remained somewhat limited. Pre-emergence application, to date, is not feasible. Light post-emergence dosages of dalapon (4 pounds per acre) or DNPB amine (1-2 pounds per acre) may be appropriate if weeds appear serious in seedings of alfalfa. Dalapon is most effective against grass weeds, the dinitros with respect to broad-leaved types. Dalapon is unadvisable if a companion crop is used. On the other hand, if the legume is protected by a companion crop, light dosages (1/4 pound per acre) of 2,4-D or MCP are sometimes suggested. Legumes are less sensitive to the new still experimental 2,4-DB than to 2,4-D, and this chemical may be released for use within the next few years. Possibly, as some workers have suggested, appropriate herbicidal treatment can, in time, substitute for the weed control functions of the companion crop.

The use of herbicides in established legumes for forage and hay is, in general, inadvisable. Aside from crop injury and residue considerations, mowing will better hold perennial weeds in check than light herbicide treatment. However, dormant alfalfa can be treated with CIPC, DNPB, or TCA, but some injury may ensue. For alfalfa seed production, CIPC (6 to 8 pounds per acre for dodder) and diuron (2 to 3 pounds per acre commercial preparation) have shown up well in trials.

In legume (usually alfalfa or white clover)-grass mixtures, the above-discussed cultural procedures have similar application. The usefulness of chemicals is limited. 2,4-D or MCP (amine, 1/2-3/4 pound per acre) are sometimes employed in Ladino-grass combinations. The treatment should not be attempted until the clover is well past the seedling stage; injury is a hazard. DNPB may be employed in alfalfa-grass combinations, as above described, but light dosages are advisable.

If the stand consists entirely of perennial grasses (brome, fescue, etc.) 2,4-D or MCP may be valuable in elimination of broad-leaved weeds, particularly in seed fields. Dosages of 1/2-1 pound per acre can be employed. As with other grasses, the seedlings and boot-to-head stages should be avoided.

PASTURES AND RANGE LAND

Here we are considering permanent pastures or ranges. They are areas in grasses or grass-legume mixtures which serve for grazing or hay. They are not susceptible to cultivation. Hence, crop rotation, a basic weed control method, is unavailable. As a consequence, many of the weed kinds are species which rarely occur in cultivated land. On the other hand, some of the common weeds of row crops *(Amaranthus, Setaria, Polygonum)* are infrequently found in permanent grassland.

Pasture weeds include all life cycle groupings: annuals, biennials, both herbaceous and woody perennials. Annual and biennial weeds are sometimes limiting factors in the establishment of new seedings, and may become overwhelmingly abundant in run-down or overgrazed pastures. Unpalatable or spiny plants, e.g. mullein *(Verbascum)* or thistles *(Cirsium)* are sometimes prevalent. On the other hand, in vigorous, established crop stands, annual weeds are usually at a minimum; perennial kinds may be more successful in persisting.

Most pasture weed infestations result from improper management and overgrazing. If grasses and legumes are maintained in a healthy condition, weeds rarely become a problem. If improved management procedures are not undertaken in connection with measures to get a weed problem in hand, weed control will never be completely successful but will be a recurring problem.

Mowing or the use of 2,4-D are the usual control methods. Recent studies comparing the effect over several years of a single mowing versus one 2,4-D treatment have indicated the chemical to be the more effective in the gradual suppression of perennial weeds. However, mowing is probably the most effective method of weed control in many pastures, in virtue of the frequent presence of legumes if for no other reason. Two treatments a season (latter part of June and middle of August) will prevent seed production by most annuals and will inhibit spread of perennials. The combination of mowing and fertilizing is often highly effective in reducing weed problems to a minimum.

If the area is one not susceptible to mowing and if legumes are not a consideration, the use of 2,4-D may be advisable. Best times of application will depend upon the nature of the weed infestation; as a general rule, two applications a year, June and August, are best. Treatment will probably have to be continued two years for most perennial weeds. The rate of application may depend upon the nature of the infestation as well as the formulation used. The esters are commonly employed. One-fourth pound per acre will kill ragweed, but one pound is frequently required to allow control of weeds such as Canadian thistle. 2,4-D has been found to improve Kentucky bluegrass seed production when applied to pasture areas to be stripped. The reasons for the increased seed set have not been entirely clarified; they do not appear to relate to weed elimination.

In some instances, or as a last resort, pasture renovation involving liming, disking, fertilizing, and reseeding may be the logical procedure. Mowing incipient annual weed infestations may aid stand establishment. Herbicides are not frequently employed. Dalapon (5 pounds per acre) has been suggested for use against annual grasses in new seedings of birdsfoot trefoil.

As indicated in an earlier chapter, animals should not be allowed access to vegetation treated with 2,4-D for a period of 10 to 14 days.

BRUSH IN PASTURES

Brush includes shrubs, vines, and small trees which have little value for wood and which compete with pasture grasses and legumes.

Brush plants are, therefore, weeds. Examples: buckbrush *(Symphoricarpos)*, box elder *(Acer)*, alders *(Alnus)*, sumac *(Rhus)*, wild grapes *(Vitus)*; larger trees: elm *(Ulmus)*, hackberry *(Celtis)*, poplar *(Populus)*.

A large proportion of the permanent pastures in the North Central states possess brush to a greater or lesser extent. The same generalities apply to brush as to other kinds of pasture weeds. The problem frequently arises as a consequence of overgrazing or mismanagement; the application of control procedures without an accompanying improved land use program will bring no permanent solution. Removal of brush should often be followed by fertilization and reseeding; otherwise, its place will merely be taken by other weed species.

Small brush (shrubs, vines) may be mowed with a brush bar attachment on a mower and regrowth sprayed if necessary. Initial spraying rather than mowing may be employed, but kill is often not as complete as on the young, regrowing sprouts. Brush killers, 2,4-D and 2,4,5-T mixtures, 3/4 to 1 pound in 25 gallons of water, are usually recommended for foliage spraying. Ammate, 1 pound per gallon of water, is also satisfactory.

Larger trees can be (1) destroyed by foliage spray applications, "basal" treatment or soil sterilants and left standing, or (2) cut, followed by stump treatment to prevent regrowth or spraying to kill regrowth.

Foliage application is as above described. Basal treatment consists of spraying brush killer in oil (3/4 to 1 pound in 5 gallons) on the lower foot or so of the tree trunk and wetting it to run-off; usually this is done during the dormant season. If instead, the trees and brush are cut, the regrowth foliage can be sprayed in early summer, or the stump can be treated to prevent resprouting. With respect to the latter procedure, brush killer formulations in oil are frequently used. It is desirable to loosen the bark around the edges to aid penetration and to wet thoroughly. Ammate can be employed for the same purpose. If applied dry (2 to 3 tablespoons per 4 inches of stump diameter), ammate should be poured in holes drilled in the wood or around the edge of the loosened bark. It may also be used in water solution (3 to 5 pounds per gallon). In addition to inhibiting resprouting, ammate speeds decomposition.

In certain situations, the use of soil sterilants may constitute the easiest way of eliminating unwanted brush. Urea compounds, fenuron and monuron are applicable. They are applied to the soil, either by spraying or dry (pellets).

LAWN AND TURF WEEDS

Lawn weeds are usually rosette, low-growing, or prostrate types. They are plants in which the leaf- and stem-forming growing points are retained close to the ground, hence can tolerate repeated mowings.

Management Practices

As in most agricultural crops, the key to lawn and turf weed difficulties is proper management. Weeds rarely become a problem in lawns which are well cared for; on the other hand, the elimination of lawn weeds by spraying will only temporarily reduce the weeds if not coupled with good management procedures.

Grasses which are not adapted to climate or soil conditions under which they are growing will do poorly against weeds. Kentucky bluegrass is the most successful lawngrass in most of the North Central states area. It succeeds best in open areas. Under trees it is readily crowded out by weeds like chickweed *(Stellaria)* and nimblewill *(Muhlenbergia)*. The use of shade-adapted grass species (fine-leaved fescues, *Festuca;* bentgrass, *Agrostis;* shade bluegrass, *Poa trivialis*) in such areas may be necessity if weeds are to be kept down.

Bluegrass is a cool weather plant and does most of its growing in the spring and fall. Seeding, fertilization, and possible liming should be carried out during these periods to encourage vigorous growth so that the grass will gain a competitive advantage over weeds which fare better in the hot, dry period of the year. Midsummer watering should be either very thorough or completely omitted. Shallow watering usually helps the weeds more than the grass.

Herbicides

2,4-D amine will kill most broad-leaved lawn weeds. Injury to bluegrass is usually slight, but bentgrasses are more susceptible and clovers will usually be killed. The homeowner should carefully follow instructions on the container in regard to application and dosage. A knapsack sprayer or simple sprinkling can may be employed to apply the chemical. Since application is often in close proximity to susceptible ornamentals and garden plants, caution should be used to prevent careless directioning or blowing of the spray.

Application of herbicides is usually made in the spring when dandelions become conspicuous. Suggestions that treatment might be carried out in the fall have merit on the basis that the lawn can start out in the spring in more attractive condition; also, there is less chance of injury to ornamentals in the fall.

Certain other chemicals, for example MCP, may be used in the same way as 2,4-D. Some manufacturers are now preparing herbicides in granular form, sometimes in conjunction with a fertilizer so that it can be applied with a conventional lawn spreader.

Since the advent of 2,4-D, crabgrass has become the number one lawn weed in many of the North Central states. Several chemical treatments are reasonably effective in killing crabgrass seedlings and young plants without extensively injuring the established grasses. These include PMA, potassium cyanate, disodium methyl arsenate, and chlordane. They are sold under a variety of trade names. All of these weed killers have selective action against young crabgrass in contrast to the established perennial bluegrass. The latter may be subject to some injury, i.e., turn yellow, but will usually quickly recover. Since crabgrass may emerge over a considerable period of time during the summer, several applications will be necessary to catch all seedings in the susceptible stage. Treatments applied at two week intervals from May 15 to July 15 may be apropos in the middle part of the North Central states; such action should perhaps be initiated two weeks earlier in the south, two weeks later in the north. If crabgrass is to be essentially eradicated, this procedure must be continued for two years since a considerable number of seeds may carry over in the soil.

Disodium methyl arsenate is the most popular crabgrass killer at the present time. It can be applied dry or as a spray. More consistent results are usually attributed to the spray formulation. Potassium cyanate is especially valuable for older plants of crabgrass but usually yellows the bluegrass.

Crabgrass treatment may injure bluegrass seedlings. The better the start the young bluegrass has, the less will be the injury. Reseeding in the fall following treatment is probably a desirable procedure.

HOME GARDENS

Weeds have the same importance in gardens that they have on the farm. They reduce yield, crop quality, deplete fertility, and serve as hosts for insects and diseases. The majority of species are the same as those in tilled agricultural fields. Low prostrate annuals are possibly more abundant, e.g. purslane *(Portulaca)*, annual spurges *(Euphorbia)*, and prostrate pigweed *(Amaranthus)*. Strawberry beds and similar areas in which cultivation is reduced are often infested with quackgrass *(Agropyron)*, and annual or biennial weeds such as yellow sorrel *(Oxalis)*, and cinquefoil *(Potentilla)*.

The advancing science of weed control has to some extent left home gardens less touched than any other area. The majority of garden crops are easily injured or killed by 2,4-D and similar herbicides. Furthermore, the selective application of herbicides requires attention to details which the average homeowner may be unable to provide. The hoe and hand weeding are still king in the garden.

The garden should be plowed or spaded in the fall and, if possible, worked again in the spring to stimulate germination of weed seeds. Cultivation (and hand weeding as necessary) should be started as soon as the crop is discernible in the rows and continued at regular intervals.

Many gardeners let up on weed control as the crop matures and allow the entire garden to go to weeds the latter part of the summer. The abundant seed production ensuing will amply replenish the reservoir of weed seeds in the soil for the ensuing seasons. Much can be gained, in the long run, if an effort is made to prevent weeds from seeding. Little effect may be noticed the first year or two, but a gradual diminution of weeds emerging will be evident in subsequent seasons.

WEED CONTROL PROBLEMS NOT DISCUSSED

Weed control in the principal agricultural crop types in the North Central states has been treated above. It is not feasible to treat all types of weed control problems in an elementary consideration, and a number have been omitted. Among these are nonagricultural areas, highway and railroad rights-of-way, under telephone and power lines, industrial areas, drainage and irrigation ditches, ponds, etc. Vegetable crops (in which weed control is often the single most expensive production item) and orchards have not been treated. Likewise, major southern field crops have been omitted.

Information concerning these topics may be obtained from the books and bulletins which are cited at the end of this book.

30. Control of Specific Weeds

Control methods for several of the more notorious perennial weeds have been intensively studied and deserve due consideration. Not infrequently, however, complete adherence to procedures for most quickly repressing a given weed is impractical. Weed control is ordinarily geared to cropping methods, and modes of action should be prognosticated upon a total weed situation rather than a single kind. However, infestations of perennial noxious weeds sometimes become so critical that it is desirable to take specific measures against the species concerned.

The following treats some of these weeds, as well as considering a few of the better known annual kinds. However, primary consideration of annual weed problems has previously been taken up on a crop basis.

There is one aspect in which economic considerations relating to annual weed control to some extent differ from those pertaining to major perennial weeds. We have thought of annual weeds primarily on a year-unit basis, and have asked the question, particularly with respect to herbicides: will increased yield benefits (this year) justify the cost of treatment? With persistent perennials it is well to view the problem from a longer range viewpoint. An established stand of a noxious weed may materially reduce soil productivity, and likewise the actual cash value of farm land. Therefore, weed control may sometimes be given first priority, crop yield receiving secondary consideration. Likewise, the use of expensive treatments, not economically sensible on a one-year basis, may be justified if accruing benefits of several years are considered.

CANADIAN THISTLE *(Cirsium arvense)*

The root reserves fluctuate, generally following a downward trend, until bud stage, usually in June. Subsequent to flowering there is a very rapid rise. Destruction of the tops then can be delayed until flower bud formation; initial control action should be followed by subsequent cultivations or mowings at monthly intervals.

Canadian thistle is one of the few weeds which can survive an ordinary oats-legume-corn rotation moderately well — a reason it is one of the most feared weeds in the North Central states. Nevertheless, it is quite possible to prevent the weed from seriously interfering with crop production through consistent cultivation, herbicidal procedures, and the wise choice of smother crops.

Smother Crops and Cultivation

The usual smother crops are often recommended, i.e. solid planted soybeans, alfalfa, or if land is subject to erosion, sudan or forage sorghum. Alfalfa seems especially effective, particularly if thistles have already been somewhat weakened. This is perhaps because the legume recovers from cutting more quickly than the thistle. If a vigorous stand of alfalfa is secured and maintained for 2 or 3 years, a very satisfactory degree of control, if not eradication, will usually be obtained. Reasonably satisfactory results have likewise been obtained with brome as a perennial smother crop, subject areas being treated twice a year with 3/4 pound per acre 2,4-D.

Various cultivation-smother crop combinations can facilitate progress of a control sequence. For example, a Canadian thistle infestation can be fall plowed, reworked in the spring and planted to one of the annual smother crops. After harvest, fall cultivation until frost should ensue. This treatment should be followed by a perennial smother crop, alfalfa, as above discussed. Alternatively, it is possible to seed oats with no legume under-seeding and spray with 2,4-D or MCP, 1/2 pound per acre as near the bud stage of the thistle as possible, and again after harvest, 1 pound per acre.

Permanent Pastures

The thistles may be mowed at bud stage and at subsequent monthly intervals, or, initial mowing may be followed by applications of 2,4-D, 1 pound per acre. It will probably be necessary to continue this procedure for at least two seasons.

Herbicides

2,4-D is the most useful chemical. As above noted, it can be employed in pastures, and finds similar usefulness in nonagricultural areas, fence rows, along roadsides, etc. The thistles may likewise be sprayed in small grains or corn, but lighter dosages, as discussed under those crops, must be employed. Ordinarily the ester forms have been recommended; however, it has recently been suggested that 2,4-D amine or MCP may give better control as the ester kills the tops too quickly.

For small patches, a variety of soil-sterilizing chemicals, applied dry or as a spray, will eradicate Canadian thistle. Chlorates have been so employed for at least 30 years. Soil sterilants are too expensive for application in extensive stands and will temporarily take land out of production.

Among the newer herbicides, amino triazole has merits for reducing stands of Canadian thistle. It can be applied 4 pounds per acre (8 pounds commercial preparation) to young plants. After a couple of weeks the land should be plowed and planted, preferably with a late-seeded smother crop. Corn may be grown. Treatment can be accomplished sufficiently early in the spring. This procedure may be necessary a second year, or spot application may be able to essentially finish the job. The price and appropriate dosage of the amino triazole do not rule out the possibility, if conditions demand it, of using the chemical over considerable acreage. Further, it is not necessary to take the land out of production.

Effectiveness of Methods

There is much variation in experience and opinion as to success in controlling Canadian thistles with 2,4-D. There may be several reasons for this. Some farmers report considerable or complete kill after 1 or 2 applications of the chemical; others indicate the weed thrives on herbicidal treatment. First of all, there is evidence that various strains or varieties of Canadian thistle differ in their susceptibility to 2,4-D; i.e., some are easier to kill than others. Also temperature and other conditions of spray application, and the degree of vigor of the stand may affect results. There is certainly much difference between farmers as to adequacy of treatment, the degree to which directions are followed, etc. Such differences are sure to affect the successfulness of the operations on hard-to-kill weeds. Emphatically, one treatment will not eradicate most stands of Canadian thistle. The majority of "no confidence" reports seem to come from people who expected immediate success or who were casual in follow-up applications.

Controlling weeds is one thing; eradicating is another. Perhaps, in many circumstances, reasonable control is as much as is practical. Frequently, complete eradication requires hand destruction of scattered plants; seedling emergence (if both sexes of plants were originally in the field) may continue for several years more. If thistles are reduced and proper rotation and cultivation methods subsequently employed, it is usually possible to proceed without significant yield losses.

PERENNIAL SOWTHISTLE *(Sonchus arvensis)*

Control procedures applicable to perennial sowthistle are essentially the same as those for Canadian thistle, discussed above.

Food reserves are lowest in late June or early July. This, then seems the most propitious time for cultivation, mowing, or chemical treatment. One to two years of pastured grassland is effective in weakening heavy infestations. Alfalfa is an excellent smother crop for this weed, as it is for Canadian thistle, and two to three years of alfalfa will result in virtual elimination of scattered stands. Vigorous or dense infestations can be pretreated with a season of pasturing.

Chemical recommendations are essentially similar to those for Canadian thistle. 2,4-D is moderately effective, but repeated applications are usually needed.

HORSENETTLE *(Solanum carolinense)*

Methods discussed for the above two weeds are in general applicable to horsenettle.

This weed is of major importance in the southern portion of the North Central states region and south, areas in which winter cereals can be grown. The planting of these crops (wheat, barley, or oats) one or two seasons in sequence is often a practical method of reducing horsenettle infestations. After removal of the crop, the area should be plowed and worked until the next crop is put in or until frost. Since horsenettle is very late in emerging in the spring, it is then essentially treated to a fallow throughout most of its effective growing season. A follow-up with alfalfa should allow further weakening or elimination of the stand.

Soil sterilants and ammates will kill small infestations of horsenettle. 2,4-D is not very satisfactory. Some workers have felt that better success is obtained with brush killer (mixture of 2,4-D and 2,4,5-T).

LEAFY SPURGE *(Euphorbia esula)*

Leafy spurge is an early-emerging plant; food reserves are usually at a low ebb in early to middle May. The plant is notoriously difficult to kill either through cultivation or by herbicidal means.

Most successful control of heavy stands is achieved through combinations of pasturing, cultivation, and smother crops. A considerable variety of sequences of these operations have been recommended from time to time. For example, Minnesota has recently suggested (1) initial tillage followed by winter grain and cultivation alternations for several seasons, or (2) cultivation to smother crop (sudan grass) to cultivation, or (3) sheep-pastured winter grain to tillage to pastured sudan grass.

In permanent pastures, heavy grazing by sheep is consistently recommended.

As to chemical control, soil sterilants can be employed in small areas. For more extensive stands, either ammate or 2,4-D may be used with certain merits. Ammate is the more effective but its usefulness is limited by cost.

Reports concerning the efficacy of 2,4-D are somewhat conflicting. Strong dosages are necessary (1 pound per acre) to kill the above-ground parts, the immediate effect of lighter treatments being primarily restricted to inhibition of seed production. However, a succession of lighter dosage applications (1/3-1/4 pound per acre, 1 to 2 times a year), possesses a cumulative effect in reducing leafy spurge. The esters, are superior to the amines.

Assuming a reasonable degree of effectiveness of 2,4-D on leafy spurge (this is no doubt subject to geographic and genetic variation), the use of this herbicide could easily be worked into several of the above enumerated cropping-cultivation sequences. A combination method which has met with some degree of success involves cultivation followed by fall seeding of bromegrass, the stand to be maintained two years, treated May and September with 1 pound per acre 2,4-D. If 2,4-D is employed in uncultivated pastures, dosages in the neighborhood of 2 pounds per acre at bud stage and as regrowth of the weed establishes itself are probably necessary for maximum effectiveness. Such treatment should be continued two years.

FIELD BINDWEED *(Convolvulus arvensis)*

Field bindweed is an extremely deep-rooted perennial which, if well established, possesses sufficient food reserves to withstand extensive periods of cultivation. It is a major weed primarily in the more arid portions of the country, especially the western Great Plains.

Cultivation and Fallowing

Cultivation should begin no later than bud stage. After cutting, the "pull" on the root system continues at least two weeks before the new leaves are big enough to begin to send food back to the roots. Subsequent cultivations should, therefore, be at approximately 14 to 18 day intervals.

Fallowing is employed as a means of reducing bindweed in the western plains states. Sometimes it is interpolated with fall-planted grain as described below. Fallowing is less frequently utilized in the corn belt and is not recommended on land subject to erosion.

Smother Crops and Pasturing

A number of crops are capable of some smothering action on field bindweed. Annual kinds like sorghum, sudan, or soybeans can be employed. They may be followed by a perennial, e.g. alfalfa. In some areas, a spring and fall grain combination has been recommended. The spring crop should be removed as soon as practical and the ground worked several times before replanting. Any of the cereals can be employed for the fall crop, but rye, being less susceptible to winter killing, can be used farther north. The fall planting can be allowed to mature and can be harvested or, perhaps better from the standpoint of weed control, pastured. Following removal, the area should be fallowed and subsequently reseeded to winter rye or wheat. Alternatively, sudan can be employed as a summer forage. Pasturing sheep in these crops is said to be particularly effective in weakening bindweed. In subsequent seasons, the land should be planted with alfalfa or perennial grass.

Chemicals

Soil sterilants (sodium chlorate, monuron, borax, TBA) can be used for small areas. TBA, a relatively new herbicide, is said to have a considerably shorter effect on the soil than other sterilants.

Diverse results have been reported from the use of 2,4-D. Its employment appears to have been more successful in the humid portions of the North Central states than in the drier areas. In general, 1/2 to 1 pound per acre acid equivalent of this chemical, first applied at bloom stage and repeated several times, will hasten elimination of the bindweed. The 2,4-D can be employed in conjunction with the smother crop and pasturing sequences discussed above. In the corn-belt area it is possible to spray twice in oats (without legumes) and corn. If an oats to corn to soybeans sequence is employed, the land should be worked following combining or cutting of the small grain.

Seedlings

Even though a perennial infestation has been eradicated, the soil may contain numerous long-lived seeds which will continue to emerge in subsequent years. Up to approximately the 5-leaf stage, these seedlings behave like annuals. About this time the roots become capable of sending up more sprouts. Such seedlings can no longer be destroyed by merely cutting off the tops.

QUACKGRASS *(Agropyron repens)*

Quackgrass spreads from shallow, creeping rhizomes which grow close enough to the surface to be accessible to destruction. It is a cool season crop, succeeding best in moist soils. Aggressive growth takes place primarily in the spring and fall.

New infestations may arise from pieces of the rhizomes if these are inadvertently spread by farm implements. Recent work has indicated that the rhizomes have an inhibiting effect on surrounding vegetation independent of ordinary competition.

Quackgrass also produces abundant seed and is frequently spread, not only in crop seed, but in straw for mulching, in feeds, and manure.

Cultivation and Smother Crops

Cultivation procedures will ordinarily maintain quackgrass within moderate limits. Stands may be weakened both as a consequence of reducing root reserves and the drying out of rhizomes brought to the surface. Infested soil should be worked repeatedly until the crop is planted. Two week intervals, or waiting until regrowth is 2 to 3 inches high is suggested. Useful tools: disk or spiketooth harrow. Maximum cultivation should subsequently be maintained as long as possible in row-planted crops. As soon as possible after harvest, tillage should be resumed and continued till freeze up. This procedure, putting greatest emphasis on spring and fall operations is perhaps most logical in the higher moisture corn belt portion of the North Central states. On the other hand, further west, greater emphasis should be given to mid-summer tillage procedures which bring rhizome fragments to the surface of the soil.

Efficient cultivation will usually prevent quackgrass from interfering with reasonably successful crop production. It probably will not eliminate the weed. The efficacy of cultivation is greatest in lighter soils, and under moderate rainfall. It may not be entirely successful in low heavy soils.

Smother cropping plus cultivation may be helpful. Quackgrass is not as easily smothered as some perennial weeds but solid-planted soybeans, forage sorghum, or sudan will weaken stands. Cultivation plus smother cropping two years in succession should result in a high degree of control.

In Grassland

Quackgrass may become progressively worse if an area is maintained in pasture or hay. If possible, the land should be thrown back into rotation. Heavy infestations of the weed may be weakened by intensive pasturing so that the sod can more easily be broken up and rendered susceptible to further treatment.

The above may not be possible in certain permanent forage areas. Perhaps disking, fertilization, and reseeding may be desirable as a means of pasture improvement. Or such a program could be initiated by prior treatment of the subject area with amino triazole (see below). Alternatively, cattle like quackgrass and it is reasonably good forage.

Chemicals

A number of chemical treatments are available for quackgrass. In many instances, particularly in extensive infestations, first consideration should be given to other methods (cultivation, pasturing, smother crops) as the use of herbicides may be an expensive alternative.

In small areas or in nonagricultural soil, soil sterilants may be the best choice: e.g. chlorates, urea compounds, dalapon in high dosages (1/8 to 1/4 pound per square rod). If resprouting occurs, a second application may be desirable.

For extensive stands in crop soil, dalapon, TCA, amino triazole, MH, or simazin are possible choices. The use of dalapon has been detailed with respect to discussion of that chemical and will not be repeated here. Amino triazole can be applied early in the season, 8 pounds commercial preparation per acre, the plants allowed to stand for a couple of weeks and then plowed under. A late planted crop, preferably a smother crop, as for example, soybeans seeded solidly, can then follow. A second year's treatment may or may not be necessary.

MH (maleic hydrazide) may be useful in small areas, i.e. gardens; application should be followed, after a week, by plowing and planting. This chemical scarcely kills the quackgrass but inhibits its growth and gives the crop a better chance to smother it.

Heavy applications of simazin (10 to 20 pounds per acre) have been shown to be capable of eliminating quackgrass. However, lighter dosages may suffice for adequate control. Recent Wisconsin studies with simazin and Atrazine, the chemicals applied fall or spring, 4 pounds per acre on land subsequently planted to corn, have yielded effective control.

PERENNIAL PEPPERGRASS *(Cardaria draba)*

Once established, perennial peppergrass is extremely difficult to eradicate, and any method except soil sterilization will require two years or more. Fallowing or smother crop procedures as previously described are applicable. Alternation of fall-seeded grain and fallowing, is sometimes practiced. 2,4-D is moderately effective, but repeated applications are necessary. If in grassland, heavy dosages (1 to 2 pounds per acre) can be utilized, two or three treatments should be applied from early bud to fall rosette stage. Application rates which can be employed in grains will prevent seed production but may not materially reduce stand.

Recent work in Idaho on irrigated land has demonstrated excellent control by combining chemical and cropping procedures. Since the weed emerges quickly in the spring, it was possible to use 2,4-D (2 pounds per acre) prior to breaking the land and planting corn. Similar, although possibly less effective, procedures were used with small grains. Weakened stands could subsequently be put in alfalfa.

RUSSIAN KNAPWEED *(Centaurea repens)*

Although declared a noxious weed in several of the North Central states, Russian knapweed is primarily a western weed. In areas to which it has adapted, it is extremely resistant to cultivation and to 2,4-D. The smothering action of perennial grasses (wheatgrasses or brome) plus continued treatment with 2,4-D will, in two years' time, considerably weaken stands. A fall-seeded grain treated with 2,4-D and alternating with cultivation may also be recommended.

JOHNSON GRASS *(Sorghum halepense)*

Johnson grass is a major southern weed which extends into the North Central states from Kansas to southern Indiana. It is a tall vigorous perennial, closely resembling sudan grass, to which it is intimately related. It differs from sudan grass in the possession of an extensive perennial underground rhizome system.

There are several means by which Johnson grass can be controlled, or its competitive importance reduced. Cultivation is perhaps the best for well established and/or extensive stands, plowing in June followed by continued tillage, over a two year period. Intervals between cultivations can be based on rapidity of regrowth; new shoots should not be allowed to exceed 6 to 8 inches in height. Stands can be significantly weakened prior to cultivation through heavy pasturing. A rotation consisting of a perennial legume, a row crop, and a small grain will not eradicate the weed but is capable of keeping it under reasonable control. A suggested combination of procedures: keep the grass down in the early part of the season by pasturing or mowing; follow with cultivation until fall. Then seed a heavy stand of winter grain and vetch. The following spring harvest and plant to corn.

Soil sterilants (TCA, dalapon, sodium chlorate, urea compounds) or oils may be employed in noncrop land or for treatment of small areas. Several applications of the oils will be required; i.e. treatment should be repeated as the grass reaches a height of 8 to 10 inches. TCA and dalapon usually have a shorter term residual effect in the soil than the other sterilants, but rather heavy dosages are needed to eradicate the Johnson grass.

Dalapon appears to offer good potentialities for chemical control of Johnson grass in larger acreage cropped areas. The chemical can be applied (20 to 40 pounds per acre) as a foliage spray subsequent to crop harvest in late summer. Follow by plowing. There will be some carryover of the dalapon but corn can usually be grown the subsequent season. Early summer treatment of the Johnson grass will likewise reduce stands but is more difficult of integration with crop production. On the other hand, if fall wheat is to follow, early summer (June) treatment may work out best. Kansas has recently reported reasonable effectiveness with dosages of 15 to 20 pounds per acre.

Inasmuch as Johnson grass ranges from the eastern seaboard to California, it is capable of succeeding in divergent agricultural areas, climates, and soil types. As may be expected, control requirements likewise differ. The above discussion relates primarily to the southern portion of the North Central states.

BULL THISTLE *(Cirsium vulgare)*

Bull thistle, a biennial, is not a major weed, but its formidable appearance and frequent abundance in run-down pastures render it an object of concern. Bull thistle cannot withstand cultivation and will quickly disappear if the area involved can be put into rotation. Mowing will prevent seed production. 2,4-D, best applied early in the season, 1 to 2 pounds per acre, will kill most plants. Scattered individuals may be spudded.

MILKWEED *(Asclepias syriaca)*

Milkweed is not a noxious weed. Nor probably is it to be classed as a major pest. But, since it is a spreading perennial, it is not easily eradicated by routine cultivation and rotation measures; furthermore, it is quite resistant to 2,4-D. It is particularly conspicuous when oats are turning yellow, for the large green leaves emphasize its presence. Frequent interest in the eradication of milkweed is expressed by farmers.

Control can usually be achieved through a combination of early season cultivation, followed by an annual smother crop, sudan or forage sorghum. After-harvest cultivation should follow. Similar treatment a second year followed by alfalfa will probably complete the job.

WILD MUSTARD *(Brassica kaber)*

This plant is primarily a weed of small grains. The use of clean seed and crop rotation should be capable of keeping it at moderate levels. It is highly susceptible to 2,4-D or dinitros as previously discussed under chemicals.

SHEEP SORREL *(Rumex acetosella)*

Sheep sorrel (also called red sorrel) is most frequently prevalent in poor pastures. Acid soils or those low in fertility give this weed a competitive advantage. Therefore, liming and fertilizations are often capable of materially reducing its prevalence. Rotation of the area to include clean cultivated and/or smother crops is likewise effective. The weed is susceptible to 2,4-D but several applications are usually necessary.

DOCKS (*Rumex* spp.)

These plants are weeds of pastures, legume stands, small grains, and roadsides. They are rapidly eliminated under cultivation; hence, rotation, including corn and soybeans, is desirable. The use of 2,4-D where feasible, especially in grassland or nonlegume pastures, will speed their destruction.

RAGWEEDS (*Ambrosia* spp.)

Ragweeds occur in agricultural areas, pastures, and legume stands (usually common ragweed, *A. elatior*) or along roadsides and in alluvial waste areas (giant ragweed, *A. trifida,* more frequent). Both kinds may occur in untended areas around towns, but the common ragweed is most abundant. Common ragweed may be controlled by improving fertility conditions, putting the area into cultivation, mowing, or the use of 2,4-D as applicable. Mowing and roadside spraying with 2,4-D are the most frequent measures employed to suppress giant ragweed.

COCKLEBUR *(Xanthium strumarium)*

Cockleburs are conspicuous annual weeds frequently abundant about farm buildings and in cultivated soil. The very young seedlings (cotyledon stage) are poisonous to hogs and the animals should not be allowed access to infested areas during the spring germination period.

A rotation including 2 to 3 years of alfalfa will deplete cocklebur seed reserves in the soil. In cultivated crops the weed can usually be held in check through early season cultivation or 2,4-D treatment (except in soybeans).

Vigorous stands of cocklebur and other broad-leaved annuals (e.g. butterprint) sometimes develop after lay-by in corn. Seed production can be inhibited by high clearance applications with 2,4-D (1/4 pound ester, 1/2 pound amine per acre). Similar mowing, spraying, or cultivation can be carried out in post harvest small grain stubble, but the latter two techniques will mean the dissolution of any legume stand. In soybeans, if cockleburs escape early cultivations, they can only be removed by hand.

DODDER (*Cuscuta* spp.)

Because of the parasitic nature of dodder and the organic connection between it and crop plants which it attacks, many ordinary control procedures are inapplicable to this weed.

The consistent use of clean legume seed to prevent infestation of dodder-free soil is of paramount importance in avoiding a dodder problem. Dodder is a secondary noxious or restricted weed in all seed laws; its presence and rate of occurrence will, therefore, be indicated on seed tags of all subject seed lots merchandised by dealers.

If land is badly infested with dodder, the planting of crops other than legumes or flax for several years will reduce the number of seeds in the soil. Such a measure will probably not eliminate the dodder, as the seeds, if not stimulated to germinate, are capable of living in the soil a number of years. A succession of mowings of legumes will usually prevent seed production and a reinfestation of the soil by the dodder.

The possible utilization of CIPC and dinitro-fortified oils has been under investigation as a means of controlling dodder in alfalfa. The use of CIPC (6 to 8 pounds per acre) in connection with seed production of alfalfa seems definitely beneficial — assuming proper weather conditions.

POISON IVY (*Rhus toxicodendron*)

Chemical control of poison ivy is now recommended whenever feasible to eliminate contact hazards in hand digging and other mechanical methods. Poison ivy can be killed by 2,4-D, brush killer, ammate, amino triazole, or soil sterilants. The method employed usually depends upon the situation in which the ivy is growing. For example, grubbing and mechanical removal may be necessary if the ivy is contiguous to valuable plants. Alternatively, it can be cut and the stubs basal-treated with 2,4,5-T in oil. Ammate can be employed in situations as in orchards where, although the poison ivy is in close proximity to the trees, most of it is not in contact with them. Applied about 1 pound per gallon of water, the leaves should be thoroughly wet. Spray should not be allowed to drift to foliage of the crop trees. Retreatments for regrowth are often necessary.

Where crop plants are not a consideration, most efficient control can usually be gained through use of 2,4-D ester or brush killer. Soil sterilants, e.g. borax compounds or chlorates, may be employed for localized areas.

VERVAINS (*Verbena* spp.)

Inquiry is frequently made concerning these conspicuous plants and other weeds which frequently become overwhelmingly abundant in permanent pastures. Their control has been discussed relative to control of pasture weeds on previous pages.

BUCKBRUSH (*Symphoricarpus* spp.)

The control of this and other brushy weeds has been treated under brush control.

FOXTAILS (*Setaria* spp.) AND OTHER ANNUAL GRASSY WEEDS OF CULTIVATED SOILS

Other major kinds may include witchgrass and relatives (*Panicum* spp.), crabgrass (*Digitaria* spp.), barnyard grass (*Echinochloa* spp.). Additional genera and species have conspicuous local importance.

Annual grasses, considering their prevalence, their rapid growth and competitive ability, and their abundant seed productiveness must, by any economic standard, be considered a (if not "the") primary weed problem in North Central states agriculture. Many of the recent developments in herbicidal weed control are directed specifically towards these plants.

Foxtail grasses and similar weeds fare best in conventional row crops, corn, and soybeans. The problems relating to their control have been treated in detail with respect to consideration of these crops. Annual grasses are not subject to the selective action of 2,4-D; hence, control is based primarily upon cultivation and pre-emergence treatment. Among current herbicides, CDAA (including Randox-T), and simazin are especially effective against germinating grass seeds.

A second aspect of the annual weed problem is the inclusion of a long term perennial, e.g. alfalfa, in the rotation picture in infested soil. Little will be gained in weak or open stands of the legume; annual grasses may thrive and set seed. But the environment created by an established, disease-resistant, well-fertilized alfalfa stand is not conducive to annual weeds. Furthermore, seed production is inhibited through mowing operations.

A third general consideration is the prevention of seed production which may restore seed reserves in the soil. This is most critical in row crops. Post-harvest mowing or cultivation may serve as a preventative measure in small grains. There is no panacea for late seed-producing grasses in corn, sorghum, and soybeans; the operator is dependent upon the efficacy of his early season weed control measures. Unfortunately some of these summer annuals are capable of germination and producing seed subsequent to the cessation of cultivation. Perhaps, in badly infested soil, a rotation could first be guided through a small grain-alfalfa sequence as a means of reducing weed seed populations before going to corn or soybeans. Efficient land use considerations would, of course, bear on any such decision.

Considering annual grasses in broader prospective, the use of clean seed is a major weed prevention tool. Forage crop seeds, and all too often soybeans, are frequently contaminated with seeds of grassy weeds. Control problems will persist if clean seed is not used.

It is sometimes observed that these are not "noxious" weeds and are not subject to restrictive legislation by seed laws. This is not entirely true. The total weed seed content (percentage by weight) must be indicated on the seed tag on all seed sold in commercial channels. It is not legal to sell crop seed if the total weed seed exceeds certain percentages, usually 1 to 3 per cent depending upon the state.

It is, of course, difficult to obtain crop seed completely free of contaminating weed seeds. However, weed seed can be reduced to a bare minimum and efforts should be made to purchase or to reclean seed so that it is essentially free of weeds. It is not difficult with present day commercial seed cleaning machinery to achieve a product of exceedingly high purity. This goal is not always attempted because a considerable proponderance of the sale market unfortunately is for cheaper, uncleaned seed.

As indicated above, the validity of the terms "noxious" and "non-noxious" as conventionally employed is becoming questionable in present-day agriculture. That the economic significance of annual grasses is beginning to receive legal attention is pointed up by the fact that Indiana has now designated tall foxtail *(Setaria faberii)* as a noxious weed and other states are considering similar moves.

31. Where Do We Go From Here?

A brief summary of weed control, some of the principles and applications, has been presented. Perhaps it is pertinent to inquire, what is next? This no one can answer with any degree of assurance. It is perhaps possible to observe, however, that the continued success and expansion of agriculture will be closely linked with the commensurate development of adequate weed control practices. The population of the United States is rapidly increasing. True, we presently seem to have overabundance — surpluses. But all prophesies indicate that this will only be a temporary condition. Future demands upon agriculture, if we are to continue to be the best fed and clothed nation in the world, will be increasingly stringent.

The following brief discussion of needs and problems makes no pretense of even partial completeness. It is presented only with the thought of stimulating further ideas.

SOME NEEDS

Among present weed control practices, pre-emergence weed control — the maintenance of weed-free conditions during at least the first part of the growing season — would seem to have the greatest potentialities. We need weed treatment chemicals which are dependable and do not present a hazard to crops. We have made much progress in this direction in the last five years; the outlook can be said to be optimistic. Also, herbicides are becoming cheaper — a necessity if widespread utilization is to be justified.

Because of the limitations of any pre-emergence treatment — which must possess selectivity between crop and weed seeds — perhaps the further exploration of preplanting herbicides will be fruitful. Such substances might possess some of the characteristics of short-lived sterilants, killing all seeds but not otherwise upsetting the biological and physical nature of the soil.

Another possible fruitful area concerns improved formulation of weed control chemicals (for example the new granular herbicides) to facilitate more efficient and effective application, and to reduce dangerous handling problems.

Various combinations of herbicidal ingredients, compatible in their activity but broadening the weed-killing potentialities of the final product are being explored in several directions. The new Randox-T represents essentially a double herbicide, the older CDAA (Randox) formulated with another chemical (TCBC). This preparation is active against not only grassy weeds, to which Randox was essentially limited, but broad-leaved ones as well.

It is difficult to eliminate persistent perennial weeds, either by chemical or other means, without interfering with ordinary land utilization. Highly toxic (to plants) chemicals are needed which can rapidly kill perennials, but which will quickly disappear from the soil.

Concommitant with the increased attention to herbicides, there has perhaps been a de-emphasis upon the biology and ecology of the plants involved, both weeds and crops. We could learn more about the life cycles of weeds, their food reserve capacities, geographical and ecological tolerances, and infra-specific physiological variability. Furthermore, with respect to an understanding of the dynamics of competition, the surface has only been scratched. All of this should substantially further our efforts to integrate total agricultural practices with weed control requirements.

SOME PROBLEMS

As stated above, better herbicide chemicals are needed. The screening, herbicidal testing, and experimental formulation of chemicals is an expensive process. Promising substances must be field tested for a succession of years under a variety of conditions. It is necessary to assay their possible toxicity to animals in careful detail. All of this may require up to a million dollars before a single pound of a new chemical goes on the market. Obviously, only a few large firms are able to undertake such programs, and they must necessarily emphasize herbicides for those crops or purposes offering the largest potential markets. Manufacturing processes, as well as research and development, may be expensive. To what extent will herbicides be able to become cheaper? This will be decisive if the swing towards their increased utilization is to continue.

As indicated above, more dependable selective pre-emergence herbicides are needed; a more precise line of selectivity is highly desirable. This latter suggests increasing specificity of action. But how can this be accomplished? Numerous kinds of crops, physiologically variable within themselves, are grown under a wide variety of soil, climatic, and agricultural conditions. There are many kinds of weeds and most of them are diverse ecologically and physiologically. This would seem to suggest that a broadly useful herbicide should possess a considerable degree of plasticity of action. But the need for increasingly specialized and specific herbicides was above indicated. How can any herbicide or combinations of herbicides meet these requirements — and on an economic basis? In what direction should future work be conducted? Should we consider alternative means of solving weed problems?

And last, in common with other phases of agriculture, developments in the field of weed control require more know-how on the part of the farmer. He must be an expert in this as well as other fields both in production and marketing. Further investments in equipment and supplies are necessary and will probably continue. These circumstances, then, favor those farmers who are fortunate enough to possess considerable working capital, and who have scientific training and can apply it. Those not having the above prerequisites, financial or otherwise, can be expected to have an increasingly difficult time of it.

All of this seems to enhance the trend towards corporation farming, away from the traditional family farming unit. It is not for this writer to say whether this is good or bad. But weed control seems to be playing its part.

32. For Further Reading

The serious student in any line of work needs to refer to written material from a variety of sources. If he is working actively in the field, he must attempt to "keep up with the literature." Most information relating to weeds, whether in the form of books, bulletins, or in journals, may be consulted in agricultural college libraries.

Some students are desirous of assembling a personal reference collection. Books must ordinarily be purchased; they may be ordered through a bookstore or directly from the publisher concerned. Most bulletins or circulars are published by the various agricultural colleges or the U.S. Department of Agriculture. Lists of publications and specific bulletins may be obtained by writing to the publication distribution office of the agricultural institution concerned. The U.S. Department of Agriculture list of publications is available from: Office of Information, U.S. Department of Agriculture, Washington 25, D.C. There is a nominal charge for many of such publications and lists.

One may obtain periodicals or journals by subscription or by joining the scientific society which publishes the periodical. The agricultural college magazine type periodicals (e.g. *Iowa Farm Science*) are usually distributed free within their respective state. Authors (or their institutions) often obtain reprints of their articles and will furnish them free of charge upon request.

SOME JOURNALS

"Weeds." Published by Weed Society of America. Technical papers.

"Agronomy Journal." Published by American Society of Agronomy. Technical papers.

"Crops and Soils." Published by American Society of Agronomy. Popular reports and abstracts or news notes of recent findings.

"Plant Physiology." Published by the American Society of Plant Physiologists. Technical papers.

Of the above, the journal "Weeds" is devoted exclusively to this topic. The others include reports of weed control investigations along with other agricultural and basic plant science subjects.

Many other technical journals likewise contain research papers dealing with various phases of weed control. Numerous semi-popular farming magazines (e.g. Soybean Digest, Better Farming Methods) and the agricultural college periodicals include articles summarizing recent developments.

SOME BULLETINS AND BOOKS RELATING PRIMARILY TO WEED CONTROL

Because of rapid changes in the weed control field, there has been a shift away from formal bulletins or circulars as a source of information release. These have been replaced by articles in agricultural college periodicals or mimeographed summaries. In this form, recommendations can be more easily revised and brought up-to-date as required. Such material is usually available from publication distribution offices of agricultural colleges.

Attractively-prepared informational releases concerning herbicides and their employment are usually available from the major chemical manufacturing companies.

The following includes only formal books, certain bulletins and circulars.

Ahlgren, G. H., G. C. Klingman, and D. E. Wolf. Principles of weed control. 368 pages. John Wiley and Sons, New York. 1951.

Andrews, O. N. Chemical weed control, Alabama Agr. Ext. Serv. Circ. 507. 1957.

Baker, L. O., *et al.* Weed control in Montana. Mont. Agr. Exp. Sta. Circ. 210. 1956.

Behrens, R., *et al.* Cultural and chemical weed control in Minnesota. Minn. Extension Folder 191. 1959.

Derscheid, L. A. and K. E. Wallace. Weed control research in South Dakota. S. Dak. Agr. Exp. Sta. Circ. 122. 1956.

Dunham, R. S., *et al.* Quackgrass control. Minn. Agr. Exp. Sta. Bull. 434. (North Central Reg. Publ. 71.) 1956.

Hauser, E. W. and H. Fred Arle. Johnson grass as a weed. U.S. Dept. Agr. Farmers Bull. 1537. 1958.

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Klingman, D. L. and M. K. McCarty. Interrelations of methods of weed control and pasture management at Lincoln, Nebraska, 1949-55. Nebr. Agr. Exp. Sta. Tech. Bull. 1180. 1958.

North Central Weed Control Conference. Research summaries. Reprint from Proc. North Central Weed Control Conference. 15:49-81. 1958. Contains concise technical summaries prepared by various specialists. These include recommendations for control of various noxious weeds, weed control problems in specific field and horticultural crop kinds, and miscellaneous topics. A brief supplement to the above, including new research findings, was published in 1959.

Phillips, W. M. Weed control in sorghum. Kans. Agr. Exp. Sta. Circ. 360. 1958.

Robbins, W. W., A. S. Crafts, and R. N. Raynor. Weed control. 2nd ed. 503 pp. McGraw-Hill Co., New York. 1952.

Spurrier, E. C., *et al.* Chemical control of weeds and brush. Ill. Agr. Ext. Serv. Circ. 771. 1957.

Trevett, M. F. and H. J. Murphy. Chemical weed killers — 1958. Maine Ext. Serv. and Agr. Exp. Sta. Misc. Publ. 632. 1958.

PUBLICATIONS RELATING PRIMARILY TO WEED IDENTIFICATION

Crooks, D. M. and L. W. Kephart. Poison ivy, poison oak, and poison sumac: Identification, Precautions, Eradication. U.S. Dept. Agric. Farmers' Bull. 1972. 1958.

Drew, W. B. and C. A. Helm. Representative Missouri weeds and their control. Mo. Agr. Exp. Sta. Bull. 443. 1941.

Fernald, M. L. Gray's manual of botany. American Book Co., Boston. 1632 pp. 1950. (This and the book by Gleason are botanical manuals treating all plants of the northeastern, and, in large part, the North Central states. The use of books such as these is necessary if less common species not treated in weed books and bulletins are to be determined. The efficient use of botanical manuals requires a good knowledge of descriptive botany and terminology pertaining thereto.)

Fogg, J. M. Weeds of lawn and garden. 215 pp. University of Pennsylvania Press, Philadelphia. 1945. (Illustrations and popular discussion.)

Gilkey, H. M. Weeds of the Pacific Northwest. Oregon State College. 441 pp. 1957. Illustrations and descriptions.

Gleason, H. A. Illustrated Flora. 3 vols. New York Botanical Garden, N. Y. 1952.

Hitchcock, A. S. and Agnes Chase. Manual of the grasses of the United States. U.S.D.A. Misc. Publ. 200. Rev. 1950.

Kummer, Anna P. Weed seedlings. 435 pp. University of Chicago Press, Chicago. 1951. (Illustrations and descriptions of seedlings.)

Leasure, J. K. Some common weeds and their control. Tenn. Agr. Exp. Sta. Bull. 213. 1950.

Muenscher, W. C. Weeds. The Macmillan Co., New York. Rev. ed. 1955. (The standard text on weed identification for the United States. More than 500 kinds treated, the majority illustrated. Only slightly revised from older 1936 edition.)

North Central States Regional Committee. Weeds of the North Central States. Ill. Agr. Exp. Sta. Circ. 718. (North Central Reg. Publ. 18.) 1954. (Available from mailing offices of any of the stations in this region. Price 75¢. The most valuable identification bulletin for the North Central states.)

Robbins, W. W., M. K. Bellue, and W. S. Ball. Weeds of California. Calif. Dept. of Agr. Rev. ed. 1951. (An excellent treatment of West Coast weeds containing descriptions and both black-and-white and colored illustrations.) Available from Supervisor of Documents, 214 State Capitol, Sacramento, California.

Schrader, L. L., R. C. Kinch and E. Sanderson. South Dakota weeds. State Weed Board Publ. 5. 1950.

State of Nebraska. Nebraska weeds. Nebraska State Bull. No. 101. Rev. 1952. (Obtain from Nebraska Division of Noxious Weeds, State House, Lincoln, Nebraska.)

WEED AND AGRICULTURAL SEED LAWS

Copies of state laws can usually be obtained by writing to the Department of Agriculture (or its equivalent) in the state concerned.

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* The author acknowledges the editorial assistance of Mr. A. L. Larsen in the preparation of the index.

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