

Some Thoughts About Weeds

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What Is a Weed?

The word "weed" comes to us from Middle English and has Flemish, Frisian, and Anglo-Saxon roots. The Oxford English Dictionary (OED) says that "the ulterior etymology is unknown." The word appears in English literature at least by the time of Alfred in the 9th Century. The early usage appears to be compatible with the first definition given by the Oxford English Dictionary: "*Weed* 1. A herbaceous plant not valued for use or beauty, growing wild and rank, and regarded as cumbering the ground or hindering the growth of superior vegetation." It should be pointed out that another word, "weed," meaning clothing, garb, armour, or covering (e.g., "widow's weeds") has a different etymology and comes from Teutonic and Scandinavian roots.

The first definition given by the OED has generally been satisfactory until recent times. Metaphorically, weed has been used for tobacco, for horses that might well be culled from the herd, and spindly or ungainly people; but on the whole, usage of the word has been in general conformity to the definition given. In recent decades, however, the words—"weedy," "weed," "weediness" or "weedishness"—have taken on fresh implications that we believe have not been adequately discussed nor critically defined in published form.

A Weed Is Unwanted

The first ten definitions listed in Table 1 are by professional weed men. The list could be extended considerably, but obviously, they are all in agreement and have either copied their definitions from each other or from the same dictionaries. It is, perhaps, understandable that the professional weed men should emphasize the unwanted aspect of

weeds; their bread is buttered by the undesirability or "unwantedness" of weeds.

We agree that weeds are generally unwanted, but we cannot agree that this should be the ultimate criterion for calling something a weed. The professional weed men are inconsistent on this point. In each of the cases cited, the author, having defined a weed as a plant out of place or an unwanted plant, then proceeds to give long lists of "weeds" as though weeds were species. They also frequently speak of the qualities of "weediness" or "weedy habits," and in no case are they referring to a degree of unwantedness. Despite the sameness of the definitions, it is evident from the usage of the word that a weed is a weed because of something it is or does and not simply because it is an object of prejudice.

Some 30 years ago, the combination of a severe economic depression and a protracted, intensive drought caused extensive abandonment of farm lands throughout the Great Plains. In the first or second year of abandonment, thousands upon thousands of acres were covered with solid stands of either Russian thistle or weed sunflower. These two species, the one alien, the other native, are on everyone's weed list. But, did these plants suddenly lose their status as weeds when the farms were abandoned? On the day of abandonment did these plants become something else because there was no one there to not want them? As a matter of fact, these and other species like them suddenly became very valuable plants by covering the soil and reducing wind and water erosion on the abandoned fields. Yet, we submit that most people would still call them weeds.

It is our contention that whether man wanted them or not had little to do with it. The Russian thistle and the weed sunflower are weeds primarily because of the habitats they occupy, and man's attitude toward them is secondary. Bunting (1960) challenges the current definitions in these words:

"The common definition of a weed—that is a plant in the wrong place—conceals

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two important implications. Firstly, the word 'wrong' implies a human opinion, since right and wrong are human concepts not inherent in nature. Secondly, the word 'place' implies some characteristic dependence on environment, or in other words an ecological relationship, and clearly that relationship has to do with man's own botanical activities in farming."

He then defines weeds in ecological terms as "pioneers of secondary succession" (Table 1). The use of the adjective "weedy" clearly reveals that we have defined "weed" one way

but use it another. For example, Bunting (1960) states: "In parts of West Africa, the weedy *Digitaria exilis* is an important crop." But, "weedy" only incidentally has anything to do with wantedness or unwantedness. It has to do with ecological behavior.

Rademacher (1948), faced with the same problem in defining a weed in German usage, gave two definitions (Table 1): one for the biologist and one for the agriculturalist.

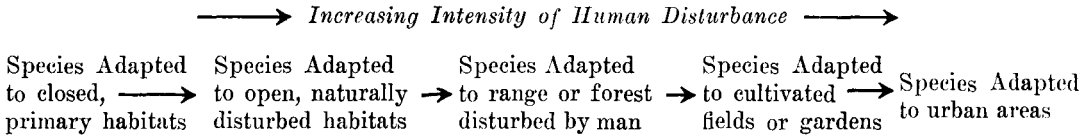
There are, then, two traditions with respect to weeds: one based on ecological behavior and one on man's response to the spe-

TABLE 1. DEFINITIONS OF WEEDS

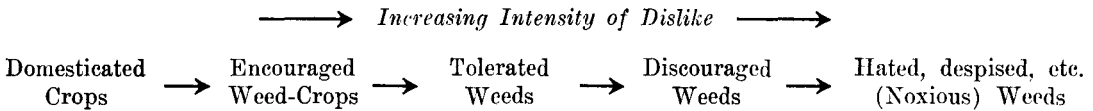
A. By Professional Weed Men		
Blatchley	1912	"a plant out of place, or growing where it is not wanted."
Georgia	1916	"a plant that is growing where it is desired that something else shall grow."
Robbins et al.	1942	"these obnoxious plants are known as weeds."
Fogg	1945	"any plant which grows where it is not wanted."
Muenseher	1946	"those plants with harmful or objectionable habits or characteristics which grow where they are not wanted, usually in places where it is desired that something else should grow."
Harper	1960	"higher plants which are a nuisance."
Isely	1960	"any plant where it is not wanted, particularly where man is attempting to grow something else."
Salisbury	1961	"a plant growing where we do not want it."
Klingman	1961	"a plant growing where it is not desired; or a plant out of place."
Wodehouse	1963	"an unwanted plant."
B. By Enthusiastic Amateurs		
Emerson (in Blatchley)	1912	"a plant whose virtues have not yet been discovered."
Cocannouer	1950	"—This thing of considerin all weeds as bad is nonsensical!"
King	1951	"weeds have always been condemned without a fair trial."
C. By the Ecologically Minded		
Bunting	1960	"weeds are pioneers of secondary succession, of which the weedy arable field is a special case."
Anderson	1953	"artifacts," "camp followers."
Blatchley	1912	"a plant which contests with man for the possession of the soil."
Dayton	1950	"introduced plant species which take possession of cultivated or fallow fields and pastures."
Pritchard	1960	"opportunistic species that follow human disturbance of the habitat."
Isely	1960	"the prime characteristic possessed by all important weeds is their ability to thrive in land subject to the plow."
Salisbury	1961	"the cosmopolitan character of many weeds is perhaps a tribute both to the ubiquity of man's modification of environmental conditions and his efficiency as an agent of dispersal."
Rademacher (in Kurth 1960)	1948	"Biologisch gesehen sind die Unkräuter Pflanzen, die gesellschaftsbilden mit den Nutzpflanzen zusammen auftreten, deren Kultur für sie erträglich, förderlich oder sogar lebensnotwendig ist. "Wirtschaftlich gesehen die Unkräuter Pflanzen die unerwünschterweise auf dem Kulturlande wachsen und dort mehr Schaden als Nutzen verursachen."

Zohary (1962), Braun-Blanquet (1932), Tansley (1949), Weaver (1954), Clements (1928), Hanson and Churchill (1961), Ashby (1961), Godwin (1960), Haudricourt et Hédin (1943) to cite only a few mention "weeds" in ecological contexts without either defining a weed precisely or mentioning their unwantedness. Clearly, to them, weeds are species with certain ecological characteristics.

cies in question. As might be expected of biological materials, neither criterion is sharp nor clear cut, and there are gradations between the extremes. With respect to ecological adaptation, the gradients might be diagrammed as follows:



Under the heading of species adapted to human disturbance, we might also diagram various degrees of human response:



One difficulty in using the test of “unwantedness” to define a weed is that one man’s weed is often another man’s crop. The wild oat may be a serious pest to the California wheat grower; but, to the cattlemen of the coast and foothill ranges, the wild oat may be his most important forage. Johnson Grass may be a hated weed to the Texas cotton farmer, but a valuable hay crop to his neighbor. The weedy watermelon, *Citrullus vulgaris*, is an obnoxious weed in cultivated fields over much of tropical and subtropical Africa, but it is often the only supply of water for man and beast alike in the Kalahari Desert (Story 1958). A man may fight *Cynodon dactylon* with a passion in one field, deliberately plant an improved variety in another field and nurture still another variety with tender care about his house. On the whole, it must be admitted that the human response is more capricious than inherent ecological behavior.

A Weed Is Adapted to “Disturbed” Habitats

Those who think of a weed in ecological terms generally agree that weeds are adapted to “disturbed” or unstable habitats. By this we generally mean pioneers of secondary

succession, but it is pertinent to establish the kinds of disturbances and the causes of instability which are applicable. In the absence of man, unstable habitats may be rather rare. One can think of river banks and frequently flooded areas, the shores of lakes, seas, and oceans, active dunes, areas unstable due to wind or water erosion, land slips, talus slopes, steep cliffs, land vacated by retreating glaciers, and the like. One would also have to consider species that occupy land temporarily following fires in forest, woodlands, and grasslands. Many forest floras include plants that temporarily exploit openings caused by blowdowns. Then there are pyroclimax species that establish themselves more or less permanently as long as the area is burned occasionally, but which might eventually disappear in the total absence of fire. Finally, animals other than man may cause widescale “disturbance,” such as overgrazing by herbivores, traffic on game trails, trampling near water holes and bedding grounds, the rooting habits of some species, the burrowing habits of others, the migrations in vast numbers of a few gregarious species, the work of termites, ants, locusts, etc.

But, are these the kinds of disturbances we really have in mind? Are plants adapted to such situations what we really think of as

weeds? By the test of unwantedness, there can be no weed in the absence of man. Ecologically, we suggest that man is equally necessary for weeds to be weeds. There is something biologically intimate about man and true weeds. A weed might, then, be defined as a generally unwanted organism that thrives in habitats disturbed by man. To a greater or lesser extent, man takes his habitat with him wherever he goes. Species adapted to this habitat are either weeds or domesticated species. The chief difference between the weeds and the domesticates is in man's attitude toward them and in his response to them. In general, man wants the domesticated species and tries by various means to encourage them; and, in general, man does not want the weeds and tries by various means to eradicate them. But, since both are adapted to the same habitat, practices that tend to favor domesticates also tend to favor weeds.

At any rate, when we specify *human* disturbances, we emphasize the extremely close relationship between weeds and man and would probably not exclude any significant organisms adapted to non-human disturbances. By this approach, if a species is "weedy," it is well adapted to some niche in the human habitat. "Weediness" refers to an adaptive syndrome which permits a species or variety to thrive and become abundant and difficult to eradicate within areas of human disturbance.

Shall We Include Animals?

As our ecological perception has increased in recent decades, the older definitions of weeds have become increasingly inadequate. A weed may still be unwanted, but more importantly a weed has come to mean something that has a certain kind of ecological behavior. If ecological behavior is to become the chief criterion for calling something a weed, should we not include animals as well? There certainly are animal species as well adapted to human disturbances as our best plant weeds. The English sparrow, the starling, pigeons, the "Norway" rat, the house mouse, *Drosophila melanogaster* and rabbits in Australia and New Zealand are examples. The striking parallels between these animals and plant weeds have been noted by Fogg

(1945), Salisbury (1961), Shelford (1913), Anderson,² Stebbins² and many others.

By the test of thriving under the influence of human disturbance, we could not exclude man. Indeed, *Homo sapiens* is perhaps the weediest of all species and the more he dominates the landscape, the more he seems to thrive. If we confine the concept of weeds to species adapted to human disturbance, then man is, by definition, the first and primary weed under whose influence all other weeds have evolved.

According to the previous section, one could also argue that man was the first domesticated animal. But man existed a very long time before he domesticated any other species; he has never seriously or consistently attempted to improve the race by selection or breeding, as he has with other domesticates; and if we apply the test of unwantedness, the current alarm over the population explosion would appear to place man more in the category of weeds than domesticated animals. If man does succeed in controlling his own population size, we shall have an example of a weed becoming domesticated.

Crop-Weed Complexes

By our definition, there were no weeds before man, but according to one theory of plant domestication there must have been weeds before agriculture. The theory of the weed-origin of crop plants goes as follows: (1) man disturbs an area, (2) the weeds move into the disturbed area, (3) man finds something useful in the weed to harvest, and, in time, (4) he learns to disturb (cultivate) the land on purpose in order to reap a better harvest from the weed now turned into a crop. The original disturbance may have been due to herding livestock, or simply to living in one place a long time and thus establishing middens, paths, refuse heaps, and the like. This "dump heap" origin of agriculture has had a number of supporters and may, indeed, have been one of the routes to plant domestication. (Sauer 1950, Anderson, 1952, Fowler, n.d.)

N. I. Vavilov (1926) had made a less radical proposal with respect to secondary crops. He did not claim to know how pri-

² Personal communication.

many crops were domesticated, but felt that once they had been established as successful domesticates they would inevitably provide habitats in which weeds would grow. Some of these weeds became so well adapted to the conditions of cultivation that they attracted the attention of primitive plant breeders and in due time became crops themselves. Rye and oats were given as examples of secondary crops.

Actually, many of our crops have weed forms. There are weed potatoes, weed peppers, weed sunflowers, weed carrots, water melons, wheats, barleys, rices, oats, and many others. Perhaps most cultivated plants have one or more companion weed forms. Generally, the weed forms are *not* more primitive than the crop and frequently show such a degree of morphological, cytogenetical, and ecological specialization that they could not possibly be progenitors of the crops to which they are related. The sequence of wild plant adapted to naturally disturbed habitats to weed adapted to man-made disturbance to domesticated crop usually will not hold up under morphological and cytogenetical analysis (Harlan n.d.).

The weed-origin theory of crop plants fails to take into account the fact that weeds can evolve just as much as crops. Thus, when we seek progenitors, we must look for species which could give rise to both the weed form and the crop form together. The progenitor of barley must also have given rise to *Hordeum spontaneum*, the progenitor of rice must have given rise to *Oryza sativa* var. *fatua* as well as to *O. sativa*. The weeds we see in our fields today may be as far removed from the wild as their companion crops.

The sequence, then, is more likely to be from wild plant adapted to naturally disturbed habitats to a crop-weed complex. The bifurcation into a crop and companion weed form may have occurred at the start of domestication, or the weed form might have developed considerably later than the crop. Some degree of introgression between the crop and weed forms seems to be characteristic of most crop-weed complexes (Harlan n.d.). In such cases, the weeds have played important roles as reservoirs of germ plasm in the evolution of the crops. The present relationship between Mexican maize and

teosinte seems to be an outstanding example of this type of crop-weed complex.

Degrees of Weediness

Whether weeds preceded crops, developed along with them, or came later as specialized ecotypes, they have surely changed since the dawn of agriculture. Just as surely we would expect various degrees of weediness among different species and races of the numerous plants called weeds. Some species are only mildly weedy; others are so completely adapted to the haunts of man that they are obligate weeds and could not exist if man ceased to prepare a habitat for them. Some species are a part of the naturally developed flora of undisturbed areas in one region and noxious and pernicious weeds in other regions. But, for the most part, plants that are really weeds show their weedy tendencies wherever they are adapted.

Species of *Opuntia*, for example, are a part of the natural vegetation of the warmer and drier parts of the Americas. They have escaped as serious pests in Australia, Africa, and parts of Asia. On the other hand, they can be weeds in America, too, and some of them respond to overgrazing and abuse of rangelands by spectacular increases in population and density. Thus, one of the ways in which weeds can be classified is into the categories of "obligate" and "facultative." The *Opuntia* spp. are facultative weeds and modern man is an obligate weed.

Zohary (1962) lists such species as *Lolium temulentum*, *Convolvulus arvensis*, and *Phalaris paradoxa* as obligate weeds and states that some of them are anecophytes, i.e., "plants whose original habitat is unknown. They, therefore, closely resemble many of the cultivated plants which have not been found anywhere in the wild state." Facultative weeds occur in both cultivated and primary habitats. They include amphioecious plants with wide ecological ranges extending from the cultivated field to "wild" habitats and pseudoamphioecious plants that are primarily adapted to cultivation but can penetrate into primary habitats under temporary human influence.

Categories of Weeds

Weeds have been classified in various ways. They have been classified according

to life cycle as annuals, perennials, biennials. They have been classified according to the places in which they grow: e.g., cultivated fields, waste places, pastures, etc. They can be classified according to the degree of unwantedness, as tolerable, noxious, damnable, etc. More pertinent to this discussion would be a classification according to the adaptations that make weeds "weedy."

In many weeds, prodigious numbers of seeds are produced, and these seeds have special adaptations that prevent all of them from germinating at once. The seeds are often small, very numerous, and capable of lying dormant in the soil for long periods of time. The dormancy may be due to a variety of special adaptations and may be broken in various ways. Some seeds are light sensitive and, when buried during tillage, may remain viable for a number of years. When the soil is turned again, some are brought to the surface and sprout. Other seeds have a cold requirement, still others contain inhibitors that break down with time or can be leached out. Some seeds are stimulated by specific chemicals, and some will not germinate except in the presence of certain other plants. At any rate, perhaps most of the annual weeds have an adaptation syndrome involving the production of enormous numbers of seeds with special mechanisms insuring that they will not all sprout at once.

Adaptive mechanisms of this kind are not confined to weeds, however. These are the sorts of mechanisms that adapt plants to short life cycles. Desert ephemerals have the same adaptations without necessarily being "weedy."

Another adaptation syndrome is one in which the weed mimics the crop sufficiently well that the seed is harvested along with the crop and sown with it at the next planting season. *Camelina nativa* subsp. *linicola* is a well known example in which races have developed that resemble particular varieties of flax in stature, posture, and maturity, as well as in seed size and weight (Tedin 1925, Stebbins 1950). Zohary (1962) cites races of *Bromus secalinus* which retain their spike-like panicles intact at maturity, unlike its congeneric species. (See also Haudricourt and Hédin 1943.) This insures that the weed will be harvested with the cultivated *Secale* in which it commonly grows as a weed. The

difficulty of separating *Lolium temulentum* from *Triticum* spp. is well known from biblical times (Matthew 13:24-30). In the United States and many other countries, extensive seed control organizations have been set up designed to restrict or prevent the sale and shipment of crop seeds that are heavily contaminated with weed seeds. Nevertheless, the transport of weed infested stock seed is one of the principal means of weed dissemination.

Most weeds are characterized by enormous phenotypic plasticity. Under favorable conditions, a given genotype may be tall, robust, well developed and highly productive. Under unfavorable conditions, the same genotype may be minute, depauperate, living but a short time and producing only a few seeds. In a paper entitled "The Weedishness of Wild Oats," Harlan (1929) described the remarkable behavior of a wild oat population in a barley nursery. The nursery contained winter forms which were still in winter rosette when spring forms in the same field were tall and heading out and some of the earliest varieties maturing. In the barley, these differences in growth habit were genetically controlled. But the wild oats with which the field was infested produced phenotypic mimics of all the growth habits. When growing with winter barley, the wild oat formed a low winter rosette; in adjacent rows of spring barley, the wild oats were tall and heading out. Where the early barley was maturing, the wild oats were ripening. All stages could be seen on the same day. The capacity for phenotypic mimicry is presumably under genetic control and constitutes an excellent adaptive mechanism for weeds.

Among perennials, most of the adaptations for weediness concern longevity. Some have rhizomes, such as *Cynodon dactylon*, *Agropyron repens* and *Sorghum halepense*. Others have deep tap roots which are difficult to kill by tillage, e.g., Canada thistle, bull nettle, and bindweed. Many of these have deep buds which can sprout from below the plow line. Other perennials are woody root sprouters which are not killed by simply cutting them down or by burning. Some of the more objectionable weeds combine qualities of persistence with other noxious features, such as thorns, stinging hairs, poisonous principles and the like. There are also some which re-

produce in great abundance, as in the annuals.

Whatever the adaptations may be, simple or elaborate, they tend to fit the weed to a particular part of the human habitat, frequently with such success that they cost us dearly in control measures. It is frequently tempting to try to transfer some of these adaptive features to cultivated plants; and in attempting to develop new forage plants, we have found it much easier to work with species that have somewhat weedy characteristics than to work with non-weedy ones.

Where Do Weeds Come From?

Generally, weeds have come from two main sources: (1) wild species that have long been adapted to sites of natural disturbance, and (2) new species or varieties that have evolved since agriculture was developed. Before agriculture, the most widescale disturbance was caused by Pleistocene glaciation. Most of Europe and great sections of North America were alternately covered and exposed. Pioneer habitats were made available on a vast scale together with ample time for species to evolve adapted to such habitats. Thus, in temperate areas around the world, the chief weeds are Eurasian and North American species that developed in or near the areas of disturbance caused by Pleistocene glaciation.

But the Pleistocene disturbance was not nearly so vast nor so rapid as that caused by man after the invention of successful forms of agriculture. There is now hardly a spot anywhere on earth untouched by man in some way. Some weedy species might have been rather uncommon before man started to churn up the landscape, but when the agricultural revolution reached them, their ecological niches were suddenly expanded, and they prospered enormously as a result.

Godwin (1960) traced the history of weeds in Britain by palynological methods. He reported some of the species to be present in interglacial times and, therefore, could hardly have been man-made artifacts. But it is usually not possible to tell a wild form from a weed form by the pollen. The later pollen cores clearly recorded the arrival of neolithic farmers by a dramatic decrease in the proportion of tree pollen and an equally

dramatic increase in weed and cereal pollen. Some of the weeds could easily have doubled as crops, for as Godwin put it: "the distinction between crop and weed was formerly less obvious than now."

Most of our modern weeds and presumably all of our obligate weeds did not exist in their present form before agriculture. They are new products of evolution. They are dynamic and labile and constitute excellent subjects for the experimental study of evolution. They are products of vast disturbances on a continental scale, where whole floras have been uprooted and replaced by imported floras and where great masses of plants separated for great periods of time are suddenly brought together under conditions promoting mass hybridization. Such a global disturbance has probably never occurred before; the result has been the evolution of new plants adapted to the new ecological niches.

Weeds come from a larger number of families than cultivated crops, and in different proportions (Table 2). We may conclude from the distribution of crops and weeds that weedy adaptations have evolved many times independently, but that only a relatively few species were found suitable for domestication. The large and diverse families have all contributed weeds (Orchidaceae, perhaps, excepted), but some have contributed only a few domesticates. On the other hand, a few of the smaller families have contributed important crop plants plus a modest complement of weeds. The great number of weeds and their wide distribution through the Angiosperms suggests that the adaptations and specializations required for weediness are under relatively simple genetic control.

Haudricourt and Hédin (1943) suggest one reason for the relative facility with which so many families and genera have evolved weeds:

"La permanence des champs cultivés sur le même sol pose le problème des mauvaises herbes. La culture du sol crée un milieu favorable au développement de certaines plantes sauvages, car elle y établit des conditions de vie marquées par une concurrence moins sévère entre les espèces."

On cultivated land, we obligingly provide a good, open, clean seedbed for the weeds to

TABLE 2
FAMILIES CONTRIBUTING CROPS AND WEEDS.

I.	MANY MAJOR CROPS; MANY IMPORTANT WEEDS Gramineae, Leguminosae
II.	A FEW CROPS; MANY IMPORTANT WEEDS Composite, Euphorbiaceae, Labiatae, Convolvulaceae, Chenopodiaceae, Cruciferae Polygonaceae, Umbelliferae.
III.	MANY MINOR CROPS; SOME WEEDS Rosaceae
IV.	A FEW CROPS; SOME WEEDS Solonaceae, Malvaceae, Palmaceae, Musaceae, Cucurbitaceae, Rutaceae, Dioscoreaceae, Linaceae, Oxalidaceae.
V.	NO IMPORTANT CROPS; SOME WEEDS Cyperaceae, Ranunculaceae, Cactaceae, Caryophyllaceae, Portulacaceae, Berberidaceae, Papaveraceae, Saxifragaceae, Geraniaceae, Onagraceae, Apocynaceae, Asclepiadaceae, Plantaginaceae, and others.

grow in year after year. When we stop providing the seedbeds and allow succession to proceed, the weeds disappear. It would seem that the adaptations required for survival in climax vegetation would be far more complex and elegant than those permitting species to flourish under human disturbance.

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