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QUELITES — ETHNOECOLOGY OF EDIBLE GREENS — PAST, PRESENT, AND FUTURE

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ABSTRACT.—Quelites are edible greens usually derived from young, tender annual herbs but they may also include flowers, inflorescences, and stem tips of perennials. Because these plant parts are available only seasonally and they do not leave recognizable macrofossils, this food resource has been difficult to detect in archaeological context. Historical references have been vague and most recent ethnographic reports contain incomplete references due to seasonality and derogatory connotations attributed to quelite consumption. Recent studies among the Tarahumara of Chihauhau, Mexico, and experimental studies in Mexico and Africa suggest that: 1) a great richness of plants is exploited, 2) human disturbance is necessary for maintenance of this resource, 3) greens form a nutritionally important component of annual diets, 4) quelites represent products of ecologically sound agricultural practices and yields are based upon the multiple cropping model, 5) encouragement of this resource may have led to the domestication of such plants as *Amaranthus, Brassica,* and *Chenopodium,* and 6) these plants may be a valuable resource in future food production systems.

INTRODUCTION

Until recently, the significance of uncultivated edible greens in the traditional native American diet has not been appreciated. As the intensity and depth of botanical, ethnological and archaeological investigations increase, practical and theoretical concepts are being applied to the elucidation of the principles of resource exploitation by man. The employment of undomesticated greens — referred to as "quelites" in Mexico — as food provides an opportunity to investigate the ethnoecology[1] of this poorly understood food resource.

The ideas expressed and part of the data presented in this paper are based upon ongoing ethnoecological-ethnobotanical studies among the Tarahumara Indians (Bye 1976). This group of southern Uto-Aztecan speakers number about 50,000 and live in the sierras and barrancas of southwestern Chihuahua. They are considered subsistence agriculturalists (maize, bean, cucurbit, and chile) who supplement a significant portion of their diet with plants procured through hunting and gathering. The statements regarding the Tarahumara are restricted to data obtained in the pine-oak forest of the sierras (2000-3000 msm) although general comments include observations in the sub-tropical barrancas (500-2000 msm) as well.

Uncultivated edible greens are generally herbaceous plants whose young leaves and tender tips are consumed. In some cases, especially in the barrancas, these "greens" may include underdeveloped inflorescences and tender, thickened stems. The Tarahumara refer to these greens as "guiribá" to which the Spanish term, "quelite," is generally applicable. These plants are usually immature when consumed and are eaten raw (in a few cases) or lightly cooked in warm water and are consumed fresh in season or dried for use during the dry season.

DISCUSSION

From the ethnoecological viewpoint, I would like to discuss 6 aspects which are being considered in formulating the general ecological principles of human exploitation of vegetal resources. These points include: 1) diversity[2] of resources, 2) importance of human disturbances, 3) measurements of productivity, 4) ecological importance of plants in agricultural systems, 5) the importance of these resources in the future.

TABLE 1.—*Some common edible greens or quelites of the Tarahumara. All of these species are commonly found in and along cultivated fields.*

Scientific Name (Arranged by Family)	Tarahumara Name Mexican Name	Season of Procurement
AMARANTHACEAE		
Amaranthus retroflexus L.	basorí, wasorí quelite del agua	spring/summer
CHENOPODIACEAE		
Chenopodium ambrosioides L.	chu'á' epazote	summer/fall
Chenopodium berlandieri Moq.	chu'á quelite de cenizo	spring/summer
COMPOSITAE		
Bidens odorata Cav.	sepé	spring/summer
Cosmos paraviflorus (Jacq.) HBK.	hu've	spring/summer
CRUCIFERAE		
Brassica campestris L.	mekuásare coles	spring/summer fall-cultivated
Lepidium virginicum L.	rochíwari	winter/spring fall-cultivated
MALVACEAE		
Anoda cristata (L.) Schlecht.	rewé	spring/summer
PORTULACACEAE		
Portulaca oleracea L.	chamó verdulaga	summer/fall
URTICACEAE		
Urtica dioica L.	ra'urí, ra'oke	spring/summer

Species Richness

Richness in the number of species and in the phenological types is an important parameter in evaluating the ecological potential of any resource system. The Tarahumara are known to employ over 120 species of quelites. Most of these plants are ingested in the form of immature leaves and stems of herbaceous dicots although a few plants have the edible portion represented by bulbous leaf bases (e.g., *Pitcarnia palmeri*), pseudobulbs (e.g., *Gongora* sp.), succulent stems (e.g., *Opuntia* spp.), and immature inflorescences (e.g., *Jacobinia candicans*). Of these 120 plus edible species, only 10 are consistently consumed today in the sierras (Table 1) and all are found in anthropogenic communities (Fig. 1).

These common species have been erroneously referred to as "wild greens" although a few researchers recognized their relationship to human disturbance (Messer 1972; Wilken 1970). Biologically, these plants are weeds which are evolutionary and ecological products adapted to survival in habitats disturbed by human activity. Without constant human interaction over thousands of years, these forms would not be present or in sufficient density to be an adequate food resource. These common quelites are annual and represent 3 major life forms which are important in the availability of culturally acceptable and seasonally distributed resources: 1) winter annuals (e.g., *Lepidium*), 2) spring-summer annuals (e.g., *Amaranthus*,

FIG. 1.—Some edible weeds form an anthropogenic community (maize fields and margins; May 1978; Cusárare, Chihuahua). Top row (left to right): *Amaranthus retroflexus**, *Chenopodium berlandieri**, *Brassica campestris**, *Lepidium virginicum**. Bottom row (left to right): *Galinsoga semicalva, Simsia eurylepis, Bidens ordorata**, *Cosmos parviflorus**, *Ipomoea hirsutula, Dalea* sp., *Anoda cristata, Urtica dioica*. An asterisk (*) denotes the preferred species. Scale equals 5 cm.

Bidens), and 3) summer-fall annuals (e.g., *Portulaca*).

It should be noted that there are only a few perennials and that the ecologically wild species play a relatively minor role in the total diet. One notable exception to this statement would include certain species of prickly-pear cacti, *Opuntia* spp., found wild in the barrancas (although it is known to be a tolerated weed, encouraged weed, or even cultivated wild plant in some regions).

Human Disturbance

Human disturbance is an important factor in determining the presence and density of these common edible weeds. They are members of various anthropogenic communities[3] which are maintained by the Tarahumara and include cultivated fields, field-fence margins, dwelling sites, corrals and trailsides. A general ethnoecological principle to be documented in the future states that the existence of large human populations depends on the net productivity of the ecosystem which is available only in the early developmental stages of succession. Based on Odum's (1969) Ecosystem Development Model (Fig. 2), net productivity[4] in an ecosystem is available for harvest, storage and consumption in the developmental stages but not in the mature stages or climax. Consequently, human activities tend to push succession back to the early stages and to maintain those stages. In these early stages, certain resources can be manipulated directly (e.g., cultivated fields) or indirectly (e.g., weed communities) so as to concentrate those exploitable resources in time and space. Recently, this principle has been illustrated in a restricted sense by the development of the "garden hunting" concept using a tropical ecosystem and animal resources (Linares 1976). The exploitation of quelites represents an analogous situation with plant resources. Interestingly, Bohrer's (1977) speculations on the food habits in

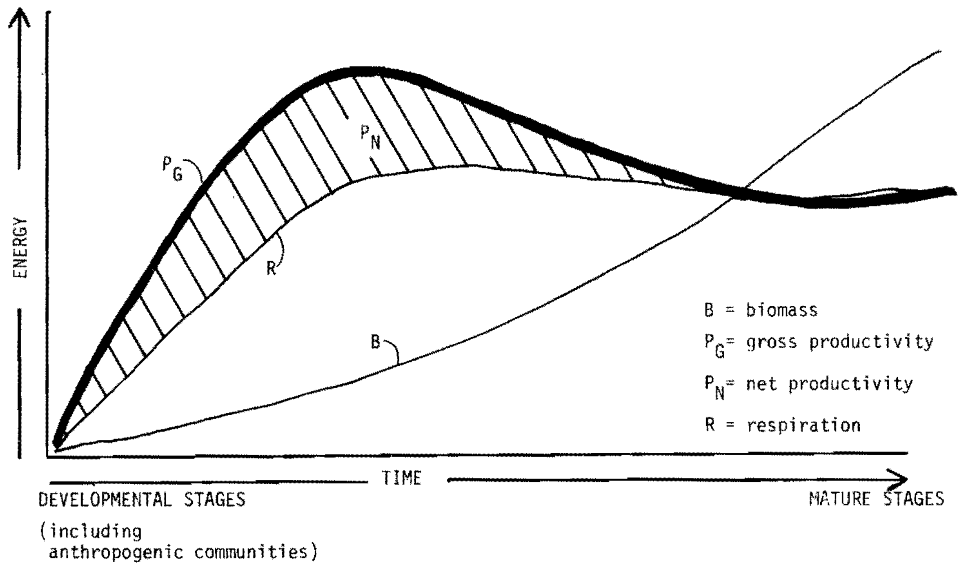

FIG. 2.—Generalized Ecosystem Development Model (after Odum 1969). Note that Net Productivity is available in the development stages and not in the mature stages.

hominid evolution suggest that plants of the early successional communities were exploited as food rather than members of the more mature communities.

Many of the characteristics of the developmental stages of Ecosystem Development (Odum 1969) are beneficial to human exploitation of concentrated resources. These characteristics include: 1) low species diversity, 2) low biomass, 3) linear food chains, 4) grazing food chains, and 5) short lived organisms with simple life cycles (e.g., annual plants). The attributes of low species diversity and low biomass may seem contradictory until one assesses the quality of the species and the biomass. In general, species richness and diversity increases with ecosystem development but the relative importance of herbs to woody plants is greater in the early stages (Fig. 3) (Beckwith 1954). The biomass is relatively low due to the nature of herbaceous annual plants which do not accumulate tissue as do inedible, woody perennials of later stages.

The presence and density of edible greens depend on several factors which are only poorly known today. Many weed seeds have evolved mechanisms for long distance dispersal (in order to colonize distant habitats when available) and for short distance dispersal (in order to increase the seed bank for maintenance of local population) (Baker 1974; Harper 1977). Disturbance (by digging, plowing, etc.) of the upper layer of the soil is critical to the germination of weed seeds so that seeds near the surface and light germinate and emerge faster than if they were deeper in the soil (Fig. 4) (e.g., Dawson and Burns 1962; Wiese and Davis 1967). The ecological importance of disturbance to light flash and seed germination has been discussed by Sauer and Struik (1964). Density of certain species in early stages of succession tends to be related to the surface area of the disturbance. Davis and Cantlon (1969) found that *Amaranthus retroflexus* tends to increase in density as the open area increases during the first year of experimental secondary successional studies in New Jersey. It is possible that agricultural practices originated, in part, in response to human preference for genetically altered plants in ecologically altered habitats. Partially domesticated plants (i.e., genetically altered from undomesticated progenitors) may have been encouraged, sown and subsequently selected in the manipulated habitats which developed into agricultural and garden habitats rather than wild progenitors of domesticated plants transferred from refuse mounds to manipulated fields and subsequently selected.

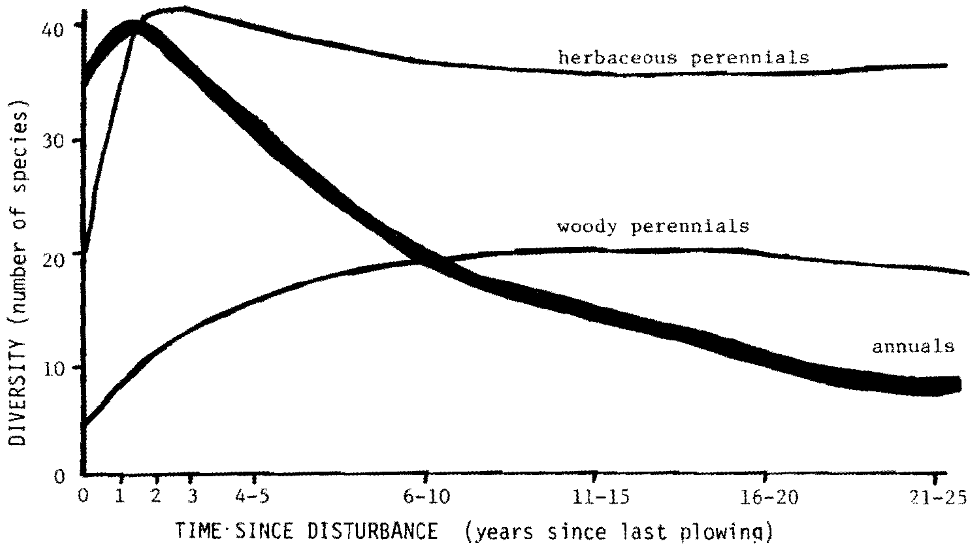

FIG. 3.—Generalized model of relative change of annuals, herbaceous perennials and woody perennials in the early stages of succession in abandoned agricultural fields (after Beckwith 1954).

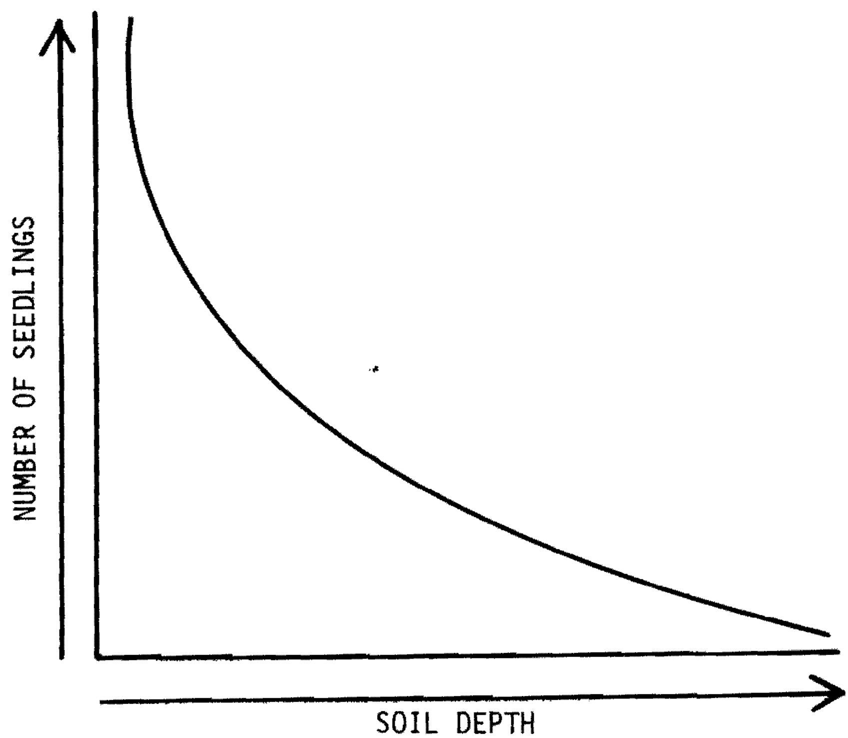

FIG. 4.—Generalized relationship of seed germination to seed depth in the soil.

Productivity

Quelites are an important primary producer of the manipulated ecosystem exploited by the Tarahumara. The significance of this productivity to these subsistence agriculturists can be measured in several ways. A few considerations are outlined below.

Being subsistence agriculturists, the Tarahumara depend on an annual diet cycle based upon maize, bean, cucurbit and chile which are consumed from fresh plants in August through October and from stored, dried forms in October through May. Often times the stored cultivated food supplies are limiting from April through July. During this latter period, the diet is augmented by hunted and gathered resources such as fish, wild greens, roots, bulbs, and "hearts" of maguey (*Agave* spp.). It is during this period that quelites from the cultivated fields dominate the diet. May-June period also marks the end of the dry season and the beginning of the rainy period and the start of the annual growing season. The seeds of weeds as well as planted maize emerge in the fields in mid to late May in response to the increased temperature and moisture. The coincidence of the marked change to warm moist regime with the germination and emergence of edible weed seedlings with the depleted food reserves is critical to the survival of the Tarahumara populations in the sierras.

The weeds can also provide food after the initial growing period. July and August may be frequented by severe hail storms which destroy the young maize plants. Also, animal pests such as crows and insects can destroy portions of the maize crop at different stages. The tender apices of the older weed plants as well as the late emerging seedlings can be collected and consumed. The quelites represent a living emerging food reserve.

When considering primary productivity in ethnobotanical terms, one must account for not only quantity in time but also quality. Although studies are in progress, preliminary data indicate that in the sierran cultivated maize fields, 100 g of edible seedlings of *Amaranthus retroflexus* (Fig. 5) can be harvested in May and early June from a plot varying from 1-4 m^2. Regeneration of another 100 g of edible weed seedlings can occur during this period in about a week. A daily serving of *A. retroflexus* consists of about 100 g per adult individual and is prepared by slightly cooking it in warm water and rinsing it in cold water 2 or 3 times and then eating it with a little salt along with tortillas or pinole.

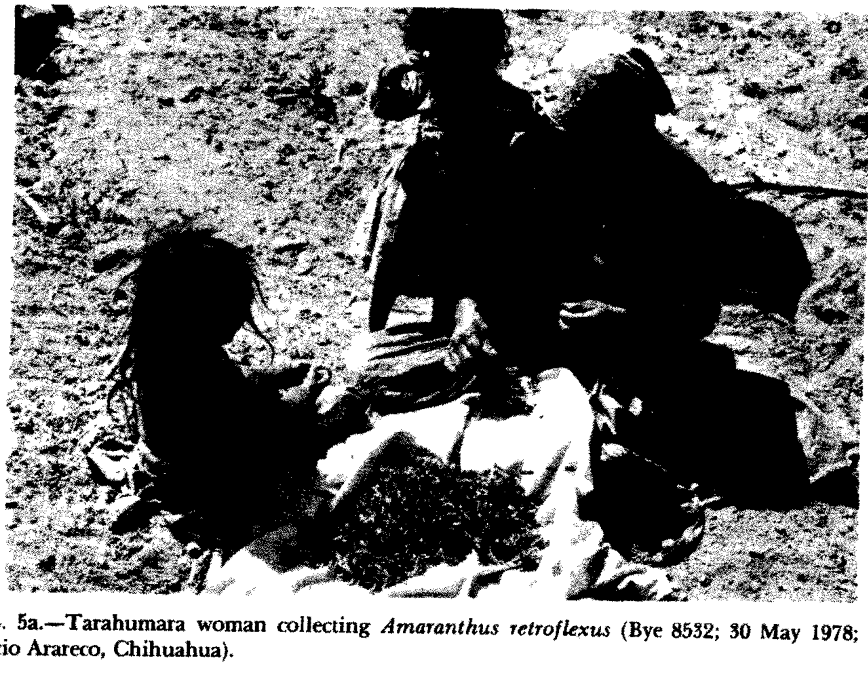

FIG. 5a.—Tarahumara woman collecting *Amaranthus retroflexus* (Bye 8532; 30 May 1978; San Ignacio Arareco, Chihuahua).

FIG. 5b—Seedlings of *A. retroflexus* at the early developmental stage when they are consumed as quelites (Bye 8510; 28 May 1978; Cusarare, Chihuahua).

The quality of quelites can be measured in several ways. One system involves cultural preference based upon beliefs and cross-cultural comparisons. For example, some Mexicanized Tarahumara no longer eat certain quelites because the dominating Mexican culture looks down upon such practices. Older Tarahumara do not eat certain species because "only the Apaches" or "only the pigs" eat those particular weeds. Another system considers the biological components such as nutritive quality, toxicity, palatability, pharmacology and flavoring.

The nutritional requirements of the Tarahumara and the value of their present diets are not known at this time. A preliminary evaluation of the Tarahumara maize-bean-cucurbit diet indicates that the following items are deficient: protein, calcium, vitamin A, thiamine, riboflavin, and vitamin C. The first 3 components are only present at about a quarter of the minimum Recommended Dietary Allowance (RDA) for an adult (National Academy of Sciences 1974) while the latter 3 components are marginally dificient. An addition of 100 g of quelites (e.g., *Amaranthus, Brassica,* and *Chenopodium*; see Table 2) has only a slight impact on the protein yet provides sufficient calcium, vitamin A, thiamine, riboflavin and vitamin C to meet the RDA standard for the United States. It should be noted that nutritional loss by traditional Tarahumara preparation techniques using warm (not boiling) water is probably minimal based upon knowledge of loss of ascorbic acid through various cooking methods (Caldwell and Gim-Sai 1973). Other preparation techniques such as sun wilting and mineral additions may enrich the value of quelites as well.

Toxic materials may be removed from food plants through selective breeding and genetic manipulation of domesticated plants or through gathering and preparation techniques applied to non-domesticated plants. The Tarahumara collect only the young, tender leaves which tend to accumulate in the older, senescent leaves which are not gathered. Aqueous cooking and leaching (rinsing) practices can also reduce the amount of these substances.

TABLE 2.—*Nutritional va... of some weedy greens (per 100 g edible portion) (Leung 1961).*

Plants	Ca (mg)	Vit. A (IU)	Thiamine (mg)	Riboflavin (mg)	Ascorbic Acid (mg)
Amaranthus spp.	313	1600	0.05	0.24	65
Brassica campestris	252	1335	0.12	0.29	118
Chenopodium berlandieri	156	2765	0.17	0.47	109
Average	240	1907	0.11	0.33	97

Palatability is another factor which affects the edibility of quelites. In general, only the young leaves and stem tips are consumed. These tender structures are relatively unlignified compared to mature tissue.

Chemical constituents of certain edible weeds may provide additional values due to flavoring and pharmacological activity. *Chenopodium ambrosioides*, a common weed along margins of fields and fences, is often added to beans and meat dishes. It imparts a distinctive flavor to the food. Also, the leaves contain ascoridole as part of the Oil of Chenopodium which is known to be an effective anthelminthic medicine (Guenther 1948-1952; Santos 1925).

The Tarahumara often collect edible weed seedlings from week 2 to week 6 after germination. After this time the plants are often too large and lignified for consumption (although the stem apices and terminal leaves can be consumed in times of emergency or famine). Recent study on the nutritional value of leaf protein in Africa included species of *Amaranthus*, *Solanum*, and groundnuts (Oke 1973). The extractable protein nitrogen, a measure of leaf protein, was found to peak during week 5 to 6 and was followed by rapid decline in nutritional value in later weeks (Fig. 6). It appears that the Tarahumara gathering of palatable leaves occurs when the potential extractable nutrient value reaches its peak.

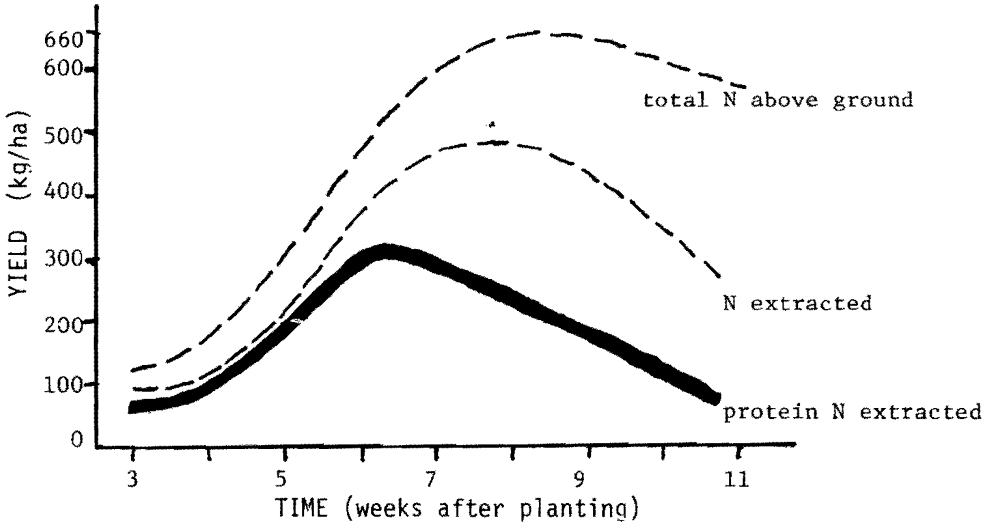

FIG. 6.—Change of nitrogen and protein content in leaves over time (based upon harvested groundnut leaves; from Oke 1973).

Ecological Benefits

Although the Tarahumara practice of leaving the weeds in the field for extended periods (Fig. 7) may appear uneconomical, this strategy may be ecologically sound. Unconscious dispersal of weed seeds by Tarahumara movements while harvesting maize during the previous year and turning over the soil for planting enables the weed seed bank to build up in the soil and to be closer to the surface to insure high rate of germination. When the weeds emerge, they are not weeded out until 6-8 weeks later. Subsequent weeding of cultivated fields at similar intervals allows for the establishment of new weed populations which provide emergency food reserves. This system allows weeds to be the first crop with the second crop, maize, being available later. This double crop system allows for the harvest of reliable yields of one type of net productivity in an environment where maximum yields of one crop systems are not possible due to poor soil fertility, limited moisture and unpredictable pests and weather.

Only recently have the practical aspects of multiple cropping systems been considered in applied techniques and theoretical terms (Papendick et al. 1976). The essence of the multiple cropping is the complementary use of growth resources by different components of the system. The rate of exploitation of each resource by each component is separated by space and/or in time. Hence, the shallow rooted amaranth weeds should be extracting water and nutrients in the upper soil surface above the deeper planted maize seeds. After a certain period of growth the roots of both species would be competing for the same resources in the same space and time, to the detriment of each species. Future research will investigate the hypothesis that the Tarahumara remove weeds when they begin to compete with maize for the same resources. Before that time (6-8 weeks) the weeds do not compete with maize and therefore should not negatively affect the maize yield. Net productivity of reliable yield therefore has 2 temporal peaks — early in the growing season with weed seedlings or quelites and late in the growing season with the harvested maize.

Tentative support for this reasoning can be seen in experimental work carried out at Chapingo, Mexico (Alcalde Blanco and Hernandez X. 1972). Plots of maize were treated with

FIG. 7.—A field consisting of two crops: 1) edible weeds (*Amaranthus, Chenopodium, Bidens* and *Cosmos*) and 2) maize. (June 1973; San Ignacio Arareco, Chihuahua).

different weeding practices. It was found that the weeds left in the fields for days 1 to 30 and for days 1 to 62 after planting had no effect on the maize yield compared to the control (weed-free plots). Maize yield decreased if weeds were left in the fields after these periods (Fig. 8). The 2 weeds used in this experiment were *Amaranthus* and *Simsia*, 2 Tarahumara quelites.

The Tarahumara concept of multiple, reliable yields appears to illustrate multiple cropping ecological theory. Weeds may also provide other ecologocial benefits such as soil protectors, dispersion of food resources for various predators, and other factors which merit further investigation.

Domestication

The exploitation of weeds may represent one pathway to domestication and subsequent agriculture. Weeds and domesticates represent end products of genetic and ecological alterations mediated by human activities (Fig. 9). Domesticates appear to be the result of human directed evolutionary changes in plants in order to increase and stabilize genetically the valued plant parts. These plants produce valued yields in a manipulated environment. Weeds, on the other hand, are not directed by conscious human selection but are evolutionary responses to human disturbed habitats which vary in time and space. As we know more about domestication, the more important weeds become in understanding this evolutionary process (De Wet and Harlan 1975).

This domestication process recognizes weeds as one type of progenitor which was suggested by Vavilov (1951) with respect to secondary centers of origin of crop plants (e.g., rye, originally a weed in wheat fields, became the domesticated grain when wheat did poorly in cultivation in northern Europe). People's response to edible resources found in human disturbed environments could trigger conscious sowing and selection of weed seeds. Domesticated amaranths and chenopods are derived from weed progenitors (Fig. 10) (Sauer 1967; Wilson and Heiser 1979) in both the northern and southern continents of the Western Hemisphere. This North-South pattern may also be present with peppergrass, *Lepidium*. Cultivated *Lepidium meyenii* is a restricted domesticate of high altitudes of South American

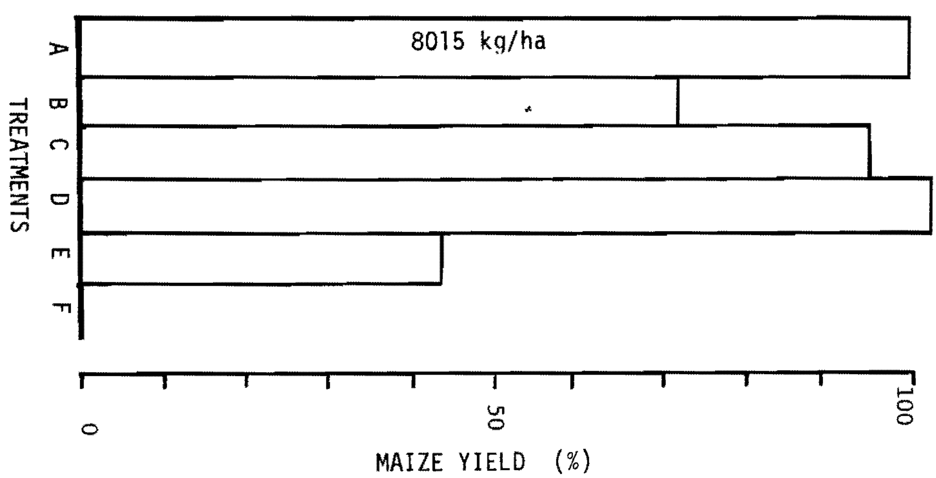

FIG. 8.—Competition study of maize and weeds (*Amaranthus* and *Simsia*) (based upon data from Blanco and Hernandez X. 1972). A, maize free from weeds at all times (control); B, maize free from weeds days 1-30 (after planting); C, maize free from weeds days 31-62; D, maize free from weeds days 63-94; E, maize and weeds together during total growing season; F, weeds alone.

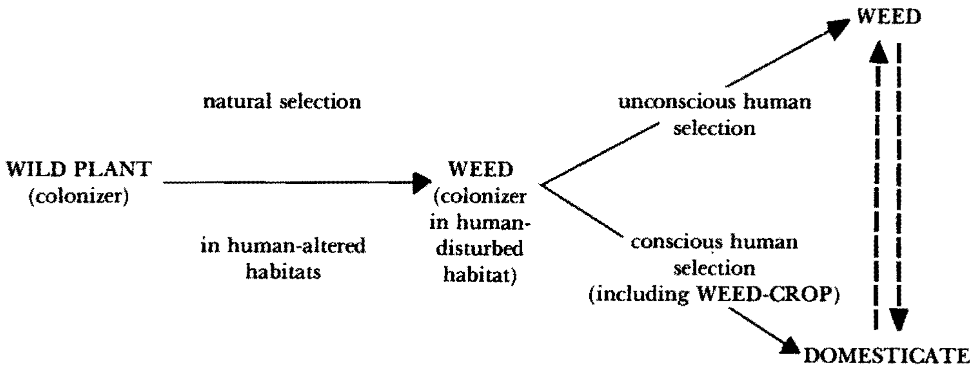

FIG. 9.—A generalized pathway of domestication involving weeds and domesticates.

Amaranthus — grain amaranths

A. powellii → *A. hypochondriacus* (sw US; nw & c Mex.)

A. hybridus → *A. cruentus* (s Mex. & Cent. Amer.)

A. quitensis → *A. caudatus* (S. Amer. Andes)

Chenopodium — grain chenopods

C. berlandieri → *C. nuttalliae* (c & s Mexico)

C. hircinum → *C. quinoa* (S. Amer. Andes)

FIG. 10.—Weed progenitors of domesticated food plants.

Bolivia and Peru (Gade 1976; Leon 1964). Although no native *Lepidium* is known to be domesticated in North America, the Tarahumara plant seeds of *Lepidium virginicum* as a weedcrop in cultivated fields (Fig. 11). Perhaps the domestication of *Lepidium* in the northern latitudes is proceeding slower. An "experiment" to examine this domestication hypothesis started nearly 300 years ago and is still in progress. *Brassica campestris*, a weedy mustard introduced by the Spaniards, has been considered a potential candidate for domestication in South America although there has been no conscious sowing and selection of this weed (Gade 1972). In North America, the Tarahumara presently have *Brassica* as a weed-crop (Bye 1979).

Future Resources

As we begin to understand the evolution, ecology and nutritional values of edible weeds, these plants can become more beneficial in the future. Strategies of germplasm conservation of economically important plants should incorporate sampling surveys of weedy relatives as

FIG. 11a.—Cultivated plot of *Lepidium virginicum*, a weed-crop.

FIG. 11b.—Plants of cultivated weed-crop, *L. virginicum*, from plot in Fig. 11a. (Bye 7040; 7119; 10, 15 Oct. 1975; east of Cusarare, Chihuahua).

well as wild progenitors. Domesticates, weeds progenitors and weed byproducts result from ongoing plant-man interactions and represent a process and not an event. These interactions involve degrees of symbiosis as well as synergism between plants and man with changes in response to various biological, ecological and cultural factors.

For our agroeconomic societies, quelites should provide new stimuli for evaluating productivity, cultural perception and value systems. A few grams of certain edible weedy greens grown in low energy input ecosystems may be more nutritious and cheaper than cultivated vegetables from high energy input industrialized ecosystems. Despite negative cultural pressure, some edible weeds (e.g., *Portulaca, Chenopodium*) are still available in Mexican open air markets and supermarkets (Fig. 12). Perhaps our young, modern civilization has a lot to learn about subsistence and productivity from older civilizations which have survived thousands of years by eating weeds as one component of their subsistence.

CONCLUSIONS

Survival of the agricultural Tarahumara populations is dependent upon edible weedy greens from cultivated fields. The diversity of plants and the ecological and evolutionary bases of their exploitation of quelites suggest that certain generalities could be drawn and

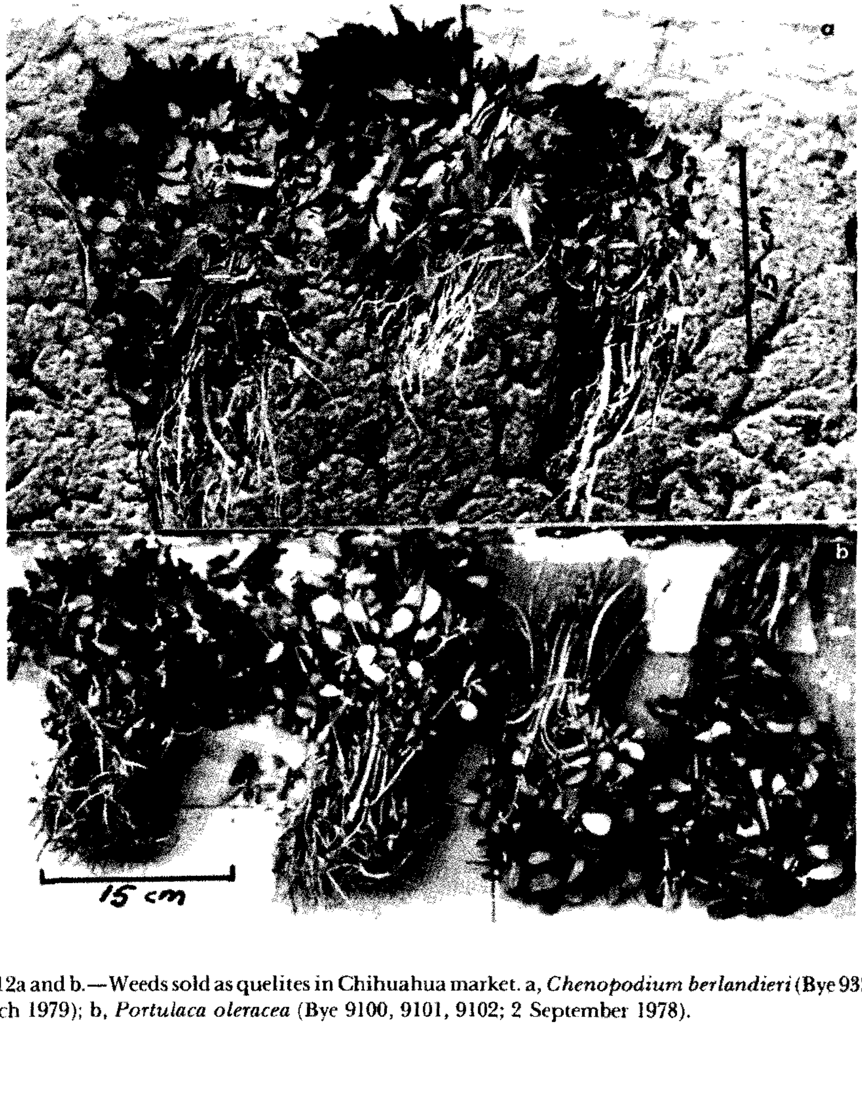

FIG. 12a and b.—Weeds sold as quelites in Chihuahua market. a, *Chenopodium berlandieri* (Bye 9322; 30 March 1979); b, *Portulaca oleracea* (Bye 9100, 9101, 9102; 2 September 1978).

applied to the development of ethnoecological principles. One principle appears to be that disturbance of the ecosystem in order to push the ecosystem back to the early developmental stages and to maintain the communities at these stages is important to the biological existence of human populations. Net productivity is available for exploitation in the early stages of succession and is subjected to variation in quantity and quality depending on human activities.

We are able to study the processes of plant-man interactions today in order to elucidate ethnoecological principles. Edible weeds are consumed by the Tarahumara. This plant-man interaction appears to be based upon biological and ecological theory. The principle of this resource exploitation should apply to other present-day cultures as well. Because these processes are evolutionary in nature, we should expect evidence of weed food resource exploitation from archaeological studies in the forms of phytoliths and epidermal tissues from coprolites, field soils, and preparation implements. This principle should also apply to the future. Once it is understood and applied, we should expect a more realistic basis for developing relationships between human populations and their ambient vegetal environment.

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NOTES

[1]Ethnoecology is the area of study which examines the ecological bases of human interactions with and relationships to the ambient environment.

[2]Ecological diversity is generally considered to consist of 2 components: richness and evenness. For the purpose of this paper, the emphasis is upon richness, which can be defined as the variety of species present in a given community. given community.

[3]Anthropogenic community is a plant community initiated and maintained by human activities and represents an early secondary successional community.

[4]Net productivity represents the amount of energy which accumulates in the ecosystem over a period of time (usually on an annual basis). It can be defined by the difference between Gross Productivity and Respiration in a given community or ecosystem.