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Ecology—Geography—Ethnobotany

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WHEN H. H. Barrows in his presidential address before the Association of American Geographers defined geography as human ecology, he had in mind the tendency among many geographers to treat their subject as the study of the relation of man to his environment.[1] The definition did not please all segments of geographers, but it did serve to focus attention on the common ground between geography and ecology. But the study of the relationship of any organism to its environment leads one into a consideration of material drawn from many specialized branches of science. Consequently, anyone who is engaged in such study cannot be narrowly specialized in subject matter, at least not within the bounds of the usual disciplines.

Disciplines composed of habitual transgressors of the usual academic boundaries must, then, be unusually heterogeneous. Geography and ecology are both marked by diversity of subject matter and by strong centrifugal tendencies. Geography has at times been despairingly defined as "what geographers do." Perhaps the same has been said of ecology. Perhaps it was such thinking that led to a symposium on the orientation of ecology.

Geographers are currently in turmoil as to the nature, purpose, and methodology of their subject. Endless hours have been wasted, barrels of printers' ink and tons of paper have been used, and precious energy has been expended on attempts at closer definitions of the subject. A historical survey shows that such controversy has raged since the early nineteenth century.[2] Undoubtedly, and most unfortunately, it will continue to rage.

Neither geography nor ecology can be defined in terms of methodology or subject matter, for these will be determined by the problem being attacked by the individual worker. Both fields share an interest in holism, the reconstruction of complex wholes. In this day of great and increasing specialization, there is need for such efforts at a synthesis of knowledge. Reality, after all, is one great unity. It is only because man has a finite brain that for ease of treatment we have split reality into small chunks, conveniently labeled biology, geology, pedology, botany, and so forth. We should never lose sight of the fact that the academic boundaries are but man-made, artificial divisions of convenience. At best they do violence to the unity of reality.

There exists a constant need for sustained and intelligent effort to reconstitute reality; to study living things not as isolated particles, but as complex organisms that exist in complex wholes in infinitely complex relationship to factors of the natural environment, which, in turn, is the result of a most intricate interaction of plants, animals, geology, soils, and climates. The need for such work is omnipresent.

A major issue is the question of the competence of any individual to achieve a holistic view of reality. In terms of a universal view the answer is surely negative. Even in terms of studies limited in time and place, it seems probable that no one man can comprehend all the ramifications of knowledge that could be brought to bear. Yet this seems no reason to reject the general attempt, in so far as we are able, to reconstruct reality in all its diversity. Even an incomplete understanding of a problem based on a multifactor approach is closer to reality than any single-factor study. A glance at the accomplishments that have resulted from multifactor studies of fish and game, for instance, shows that some investigators are capable of comprehending the principles of, and assembling data from, various fields to make noteworthy contributions to knowledge.

Few disciplines today are concerned with attempting such a holistic view. Geography and ecology, by so doing, are serving a worth-while function in an era of ever-increasing specialization. The correlation of the results of the work of specialists into more complex wholes has repeatedly led to great advances in our thinking. For example, Malin[3] has reviewed some of the effects on ecology of the successive additions of climatological, pedological, physiological, and morphological concepts to the study of the grasslands of America. Is this not justification enough for our existence? Need we waste precious time and energy in defining, delimiting, excluding? Let us rather seek knowledge and follow our interests wherever they may lead us. Let us welcome the maverick who fails to fit into narrowly defined academic fields, recognizing in him a kindred spirit who tends to view reality in broader terms and seeks to restore the interrelationships too frequently overlooked in this day of intense specialization.

Ethnobotany as a Field for Ecologists and Geographers

A field open to those unafraid to transgress academic boundaries lies in the no-man's-land between anthropology and botany and geography. This is the field of study of the relation between man and plants and animals. Here is an area where geographical, anthropological, and botanical knowledge can profitably be combined to give a fuller and more meaningful picture of the relation of man to his environment, the effect of man on plants, and the origins and routes of cultural impulses than can be gained by the use of one of these disciplines alone.

I shall here pay special attention to the plants used by man, including, of course, the domestic plants. The different groups of scientists concerned with man's use of plants have had quite distinct points of view. Ecologists, like geographers, have tended to limit their consideration of man in relation to plants to the historic picture and to modern man. The ecologist has leaned toward the nonagricultural plants; the geographer toward the agricultural ones. Ethnobotanists, on the other hand, have put special emphasis on primitive man and tended to include all plants actually harvested in some way—for example, whether for food or for house thatching.

It is probable that ecologists and geographers, too, could profitably follow the ethnobotanist and study all the plants affected by man's presence, and that all would benefit by considering a longer span of time than has been customary.

Man, Fire, and Time

Primitive man's use of fire to drive animals must have been fully as important in the past (if not more so) as fire is today in modifying vegetation. To what extent does the modern scene reflect that past? A major question, of course, is how long man has been active as a plant-modifying agent. In the Old World we have evidence for the presence of man, *Homo,* at the opening of the Pleistocene, perhaps a million years ago. Modern man, *Homo sapiens,* is present from mid-Pleistocene times on. Fire-using by man is certain from mid-Pleistocene times and may well have started earlier. Since man has never been noted for care in handling fire, and since primitive man is known long to have used fire for the purposes of driving game and improving the range, it would appear that man-set fires may well have had an influence in the Old World dating back for half a million years, and perhaps longer.

But so would many other effects of man's activities. Early man was an unspecialized gatherer. In a sense he was probably not a hunter. Rodents and reptiles and small mammals that crossed his path were undoubtedly "gathered in." But quite likely his early mainstays were fruits and buds and bulbs and seeds. Would not constant harvesting of selected species over a period of a million years have profound effects on such plant life? To what extent have ecologists studied the habits of primitive peoples for clues to the type of effect man in the Old World may have had upon his surrounding plant and animal world over the past million years?

Here in the Americas we are, of course, dealing with no such immensity of time. Until recently it has been fashionable to consider that man has been present in America but 5–10,000 years, and that he entered with a near-neolithic culture, though lacking agriculture. Today there is grudging acknowledgment that man may have been present for 15,000 years, or possibly 25,000 years, and that the cultural level of the earliest immigrants could better be likened to the paleolithic of Europe. Even these estimates are of terms of years so appreciable that men could markedly have affected our plant and animal assemblages. And yet such estimates probably fall considerably short of the mark. In our now-arid Southwest, evidence of man's presence on the shores of vanished lakes is common. Although attempts have been made to assign these to relatively recent times on the grounds of assumed post-glacial pluvial periods, no convincing climatological mechanism has yet been put forward to account for such a post-glacial pluvial. The evidence is more in favor of a Pleistocene age for these features, and a pluvial period coinciding with the last glacial period seems indicated.[4]

Field work during the past two summers on the seacoast of San Diego County, in southern California,[5] has produced evidence that man lived on this coast during the time the sea last stood low in relation to the land. This low sea stand is thought to be correlated with the removal of water from the sea and its locking up in the form of ice on the lands during Wisconsin glacial times. The evidence is associated with soils now perhaps climatically out of place and with evidence for a complex history of erosion and alluviation, with intervening intervals of sufficient length for the development of mature soil profiles. A time span equalling Wisconsin glacial time, or about 100,000 years, seems indicated. And there are tenuous bits of evidence to show that this figure may represent but half the time allowable for man's presence in America.

If man set fires annually in California for 100,000 years, what would be the effect on the vegetation, hence on the soils, and consequently on the plant and animal life? To what extent is it meaningful to try to interpret these features without considering man's role in their development? May not the widespread grasslands of central California be the result of such long-continued activity? Although I am aware that the relation of annual burning to the formation of grasslands is a difficult and controversial question, it is inconceivable to me that annual fires over any appreciable fraction of 100,000 years would fail to modify the vegetation markedly. However, here I am only trying to call attention to the fact that an ecologist, in pursuing a full understanding of how the present situation arose, should be aware of the facts that man may have been in California and elsewhere in the Americas far in excess of 100,000 years, and that man-induced fires may have been playing a role in the development of the ecology of California over this very appreciable period of time.

That fire may have played a significant role in determining the vegetative type in parts of California seems indicated by the Torrey pines. These rare trees now occupy the edge of a sandstone mesa. The soils are very thin and poor, and the trees are exposed to extreme wind action and excessive erosion. They seem to cling to the mesa almost despite the environment, rather than because of it. That there is nothing in this soil or microclimate critical for the support of the tree is suggested by the fact that Torrey pines grow elsewhere in California and the world. Where they have been planted elsewhere in the vicinity of San Diego, they have demonstrated their ability to thrive on unirrigated land in competition with the chaparral. Why, then, are they limited to the northwestern projecting tip of the Torrey Pines Mesa?

A look at this projecting mesa tip on a topographic map gives a clue. The ocean lies to the west, and wet marsh and open slough lie to the north and east. Fire could reach the tree-bearing area only from the south and by moving directly against the prevailing wind of the dry season. The evidence suggests that the pines survived in a fire-protected area, and that if protected from fires, they could today well maintain themselves over much wider areas than their present restricted habitat.

If we are correct in thinking that the Torrey pines may have been limited to their present area by fire, what might have been the source of the fires? Coastal southern California is one of the most lightning-free areas in the United States. Such lightning storms as do occur usually accompany sharp cold fronts following a winter cyclonic rain. This would be the least likely time for fires to start. For frequent fires during the dry season, man would be the most likely agent. If man either deliberately or accidentally allowed fires to run through this country, he might well have converted it from a Torrey pines forest to the chaparral land we know today. The relict, fire-protected position of the modern Torrey pines, together with their demonstrated ability to grow well over wider areas, would fit into such a theory. There are other "islands" of pines along the west coast of America. Might not a study of their locations and their climatic needs, in the light of the above, be of ecologic, geographic, and economic interest?

Other Man and Plant Relations

The California Indians were energetic gatherers of wild grass seeds. Their methods and utensils included the seed beater and seed tray. Their technique was to walk through the grasslands while striking the seed heads toward their baskets with the tennis-racket-like seed beater. By this means a quantity of seeds could be gathered in a day. But what must the effect have been on the grasses?

Such an annual harvesting must have furnished a nearly ideal seed dispersal for the grasses selected for food by the Indians. For surely not all the seeds were caught in the basket even by the most skillful Indian woman. If this process went on over a period of 100,000 years, or even 50,000 years, might there not have been selection for a grass that would hold its grain until shattered by the blow of the seed beater, which would assure it greater dispersion than could be expected in nature? Suppose some of the California grasses had been so adapted, what would have been the result of the sudden disappearance of Indians after 1800 and the sudden loss of a superior means of seed dispersal? Is the success of the Mediterranean oat in invading the grasslands of California at this time causally related to some such sequence?

These are but questions and hypotheses. We do not have the answers. But here is a field of inquiry where ecologists could contribute much of interest to geographers and anthropologists, and perhaps the findings would be not insignificant for ecology itself. For instance, one of the characteristics of our modern domestic grasses, such as wheat, barley, oats, and rye, is the loss of a fragile seed head and a consequent holding together of the seeds rather than a dispersal of them. There has been considerable speculation concerning the origin of this trait which is so inimical to the plant. May it not have developed through some such set of circumstances as related above? If man had come to specialize in gathering one grass more than others—and there are many examples among primitive peoples of such a tendency to concentrate on certain plants in their environment—the plant in question may, in turn, have become more dependent on man. The ultimate conclusion of this sequence is the purposeful propagation of the plant—that is, agriculture.

The fundamental question raised here is this: Can man use a plant over a period of 50,000 or 100,000 years without modifying the plant? Or, to state it in another way, is it not to be expected that man's annual harvesting of wild plants should become a factor affecting their dispersal and survival and reproduction rates, and hence a selective factor of some importance?

Study of the wild plants used by primitive peoples might aid in understanding the distribution of some of those plants. Recently, attention has been called to the use of *Hevea* for food by the primitive peoples of the Amazon as a factor that probably influenced the distribution and variation of the trees and probably had effects on its ultimate utilization as a source of rubber.[6] In this case, primitive man's use of the tree resulted in the establishment of many separate clones around native clearings. From the resulting high variability came great opportunities for selection. This is both an interesting and meaningful insight into man's influence on the distribution and evolution of a "wild" tree. Our knowledge of it resulted from the combination of ethnological, geographical, and botanical data. Through merging such information from these fields there are many significant findings to be made. Among such not insignificant facts is the recognition that many of the trees long treated as wild have been under human influence and modification for a great period of time.

The distribution of the peach palm (*Guilielma gasipaes*), from the eastern Andean foothills through the Amazon basin to the Orinoco basin and thence into the Caribbean, has also been suggested as perhaps due to man's use of this tree. How, then, are botanists and ecologists to know what is a "natural" distribution or a "natural plant formation" unless they have checked the plant in question against the plant uses of the peoples of the area, both past and present, in so far as they are known?

As an indication of the number of plants used by man whose distribution and evolution have probably been influenced by him, I give in Table 1 a list of plants cultivated or semicultivated within what Vavilov[7] has designated "The South Mexican and Central-American Center of Origin, Including the Antilles." It is important to note that this list covers but one part of America and is very likely incomplete.

Many years ago O. F. Cook pointed out that the tree which is now our source of chicle for chewing gum was to the Maya Indians of such importance for nuts that often the trees were left standing when a new agricultural clearing was made. When,

TABLE 1

GRAINS

Zea mays L.—maize
Phaseolus vulgaris L. Savi—bean
P. multiflorus Willd.—multiflorus bean
P. lunatus L. gr. *microspermus*—Lima bean
P. acutifolius A. Gray var. *latifolius* Freeman—tepary bean
Canavalia ensiformis DC.
Chenopodium nuttaliae Saff., *C. ambrosioides* L.
Amaranthus paniculatus L. var. *leucocarpus* Saff.—amaranth

GOURDS

Cucurbita ficifolia Bouche (*C. melanosperma* A. Braunn) —fig-leaved pumpkin
C. moscata Duch.—squash or pumpkin
C. mixta Pang.
Sechium edule Swartz.—chayote
Polakowskia tacaco Pittier (Costa Rica)
Sicana odorifera Naud.

ROOTS AND BULBS

Pachyrrhizus tuberosus Spreng. (*Cacara edulis* Kuntze)
Ipomoea batatas Poiret—sweet potato
Maranta arundinacea L.—arrowroot (Antilles)

SPICE PLANTS

Capsicum annuum L.—Cayenne pepper
C. frutescens Will.—many-leaved pepper

FIBER PLANTS

Gossypium hirsutum L.—upland cotton
G. purpurascens Poir.—Bourbon cotton
Agave sisalana Perrine—henequen; *A. ixtli* Karn.—Ichtli agave

FRUITS

Opuntia spp.—tuna
Anoma cherimolia Mill. (possible secondary center); *A. reticulata* L., *A. squamosa* L., *A. muricata* L., *A. purpurea* Moc. and Sesse, *A. cinerea* Dun., *A. diversifolia* Safford, *A. glabra* L.
Sapota achras Miller, *Sapota sapotilla* Coville—sapodilla
Casimiroa edulis La Llave—white sapote
Calocarpum mammosum (L.) Pierre—mamet
C. viride Pittier (*Achradelpha viridis* Cook)
Lucuma salicifolia H.B.K.—yellow sapote
Carica papaya K.—papaya
Persea schiedeana Nees and *P. americana* Mill. (*P. gratissima* Gaertn.)—avocado
Psidium guayava L.—guava
P. friedrichtschalianum (Berg) Niedenzu, *P. sartorianum* (Berg) Niedenzu
Spondias mombin L. and *S. purpurea* L.—Mexican plum
Crataegus mexicana Moc. and Sesse, *C. stipulosa* Stend.—*tojocote*
Diospyros ebenaster Retz.—black sapote
Chrysophyllum cainito L.—cainoto (particularly in the Antilles, in Jamaica, Panama, wild and in cultivation)
Anacardium occidentale L. (Antilles, Panama)
Prunus serotina Ehrhart (*P. capollin* DC.)—capulin (mainly wild)

MISCELLANEOUS

Agave strovirens Karw.—pulque agave, maguey
Cereus spp.—cactus for hedges
Nopalea coccinellifera Mill.—cochineal cactus
Tigridia pavonia Ker. Cawl.—cacomite (mainly wild)
Physalis aequata Jacq.—Mexican tomato
Lycopersicum cerasiforme Dun.—tomato
Salvia chia Fernald—chia (for fats)
Theobroma cacao L.—cacao
Bixa orellana L.—achiote (coloring and spice)
Nicotiana rustica L.—tobacco

in a year or two, the clearing was abandoned, the chicle trees had the greatest opportunity to fill up the clearing. It is probably to such activity, extending over thousands of years, that the chicle forest of Yucatan owes its existence.

Recently, E. C. Higbee[8] has reviewed this evidence affirmatively and pointed to a similar situation in the United States. Nut-bearing trees comprised a surprisingly high proportion of the Eastern hardwood forests. Here, too, man for a period upward of two thousand years has practiced an agricultural system built upon a long rotation, with forest cover used to restore the soil fertility to the clearings abandoned after a few years' cropping. The Eastern Indians made much use of the nut trees and quite probably left them standing whenever it was feasible. Their influence over the years must have affected the make-up of the woodlands.

But such practices were not limited to Yucatan and the Eastern United States. They were practiced in tropical South America and Middle America, and in humid Africa and Asia. In these regions, too, man must long have been modifying the make-up of the forest cover. Just what do we mean, then when we refer to "the original condition"?

Of the wild cucurbits, one has a particularly wide distribution. *C. foetidissima* is to be found from Guanajuato, Central Mexico, to Kansas and Nebraska and to the coast of Southern California. In 1944, when reviewing the distribution of the cucurbits, it seemed to me that a possible clue to *C. foetidissima's* wide range is to be found in the fact that primitive Americans ate its seeds.

Is *C. foetidissima* a domesticated plant? It has never been considered so. Its distribution has been more or less assumed to be natural. It seems quite likely, however, that its distribution is man-made and its success in entering so wide a range of ecological niches a thing to be explained in that way. M. R. Gilmore pointed out similar distributions of "wild plants" a number of years ago,[9] naming, for example, sweet flag (*Acorus calamus*), black walnut (*Juglans nigra*), and tobacco (*Nicotiana rustica*).

Man and Domestic Plants

The domestic cucurbits also pose interesting questions. There are three distinct species: *C. pepo* in North America, *C. moschata* in Middle America, and *C. maxima* in South America. Each has a putative wild ancestor in its central area. Are these, then, separate domestications? Or is this a natural degree of divergence within a species under domestication? From geographical, ethnographical, and genetic grounds, we have argued elsewhere that the divergence is best explained on the basis of separate domestication of these species.

We enter here the whole field of domestic plants and encounter the problems of the origin of agriculture and the diffusion of domestic plants. We know exceedingly little about time and place of origin in agriculture, the processes of domestication of plants, and the routes and methods of diffusion of domestic plants. Yet all these are in part ecological problems. Under what circumstances does the relationship between man and his plant world become such that certain plants are thereafter systematically propagated and selected for desirable properties? Does plant domestication have a plural or a single origin?

Until very recently it has been axiomatic that the Old and the New World agricultures were entirely separate, having no plants in common. This was in spite of the works of O. F. Cook, published over forty years ago, which indicated the improbability of this thesis.[10] Recently, a very strong case for the Asiatic domestication of cotton and its trans-Pacific transportation has been made.[11] The presence of the bottle gourd (*Lagenaria siceraria*), the coconut, and other reputedly Asiatic plants in early agricultural levels in America reopens the question of the separateness of Old World and New World agricultures.

These problems as to which are Asiatic and which are American plants are important and interesting, but perhaps less ecological than others. Surely, however, the environmental situation that gives rise to the domestication of plants is of ecological interest. The Russians, under Vavilov, began the assemblage of data that would help us to understand such a problem. Their work in the New World was rapid, and presumably many of their surveys in other parts of the world were done also in some haste. Yet they showed that there were several centers in America, each containing a characteristic group of domestic plants. The grouping of the plants was of interest. Some centers are characterized more by grain plants, others more by tuberous plants. What is the significance of this? Were tuberous plants originally lacking in the one and grain plants in the other? Would not a study of the plant, land, climate, and human relationships in some of these areas, to see what, if any, common denominator they might hold, be a problem worthy of an ecologist's attention? Other scientists, particularly anthropologists, would be interested in the ecologists' opinion on the evidence for single or plural centers of origin of plant domestication within America.

For obscure reasons, the domestic plants have received less study than their importance in our economy and their intrinsic interest would seem to warrant. Not only do we still not know the origin of maize—it is probably not a Mexican domestication, probably not a descendant of *teosinte,* and it may just possibly be an Asiatic domestic—but we are exceedingly ignorant of how, when, and where our modern commercial varieties arose. Not only does this mean that we lack information of great interest as to the times, places, and routes of diffusion in the prehistoric and early historic times, but we lack the grounds for judging adequately the corn potential of this and other lands.

The work of Anderson[12] and his colleagues is only now clarifying the origin of our cornbelt dent corns. These prove to be a compound of Northern Flints for hardiness and Southern Dents for other characters. Such studies tend to show that the corn plants now in use are a haphazard combination of a few of the limited strains available in the colonial United States. Yet the pattern is now so established that radical changes of varieties would be difficult because the farmer has an ideal as to plant size and shape, and the consumer an established ideal as to grain size, color, shape, and weight. Few of these factors are meaningful; yet their establishment as a norm has led to the development of a relatively static plant situation, and warps our judgment of man in relation to his environment in terms of corn. And the same can be said of nearly all our domestic plants.

We limit ourselves in corn-growing by trying to carry this established "normal" in corn into other areas. We tried to carry dent corn into the Dakotas and failed. We have tried repeatedly to establish dent corn among the Indians of the Southwest and failed. In this last instance, we have repeated an experiment that was tried in the same area, and likewise failed, a thousand years ago.

In our hot and arid Southwest an interesting situation exists as to beans. The Indian people of the low hot desert country have for about 2,000 years grown a particular species of bean (the tepary bean, *Phaseolus acutifolius*) which is admirably suited to great heat, little water, and high alkalinity. The Indian people of the plateau country grow a different species of bean, our common *Phaseolus vulgaris,* which is slower-sprouting, more alkali-sensitive, and subject to premature abscission of the flowers in extreme heat. On much of the plateau area and in the Rio Grande Valley, the tepary bean of the desert dweller would be ecologically better suited for growth. But because of the force of custom, the *P. vulgaris* bean is grown by modern farmers instead.

Nor may we smile at the vagaries of primitive peoples who refuse to grow the plants best suited to their ecological situation. The tepary bean, despite its many advantages—for in addition to its adaptation to hot climates it makes a nutritious forage and hay, cooks in much shorter time than *Phaseolus vulgaris* beans, and is less gas-forming—is not used today by peoples of our culture. Nor does it seem to be known in those other parts of the world where it would appear to fit into what is for man a difficult environment—for example, in arid Africa, North Australia, India, or the Near East. Any realistic assessment of the ecology of the peoples of the hot and arid lands would be incomplete if it failed to consider the possible role of this useful plant in such areas.

Similarly, our view of the problem of the settlement of the wet tropics is myopic because we have failed to integrate knowledge from separate fields. One of the needs in tropical rainy lands is tree culture. Trees are the natural vegetative cover for the area. They provide an unbroken soil cover and maintain the biological cycle of humus to plant to humus. They tend to supply a continuous crop and thereby take fuller advantage of the unbroken growing season. Trees that supply vegetables, fruit, and fibers of great variety are known in various tropical areas and have been used, and more or less modified, by native peoples. Witness, for example, the formidable and probably incomplete list from a single part of America where the native peoples have paid less attention to tree crops than did the peoples of Southeast Asia.

An ethnobotanical survey of useful tree crops of the world, followed by an attempt to construct balanced tree-crop agricultures for tropical lands, might prove to be one means of rehabilitating some of these lands, although, of course, one would even then be faced with the difficult task of persuading the native peoples to adopt the new ways. The need for some such tree-crop agriculture in tropical rainy Latin America is desperate. The economist himself would never think of such a project. The anthropologist, though he might record the plants used by native peoples, has up to now shown little interest in the possible world-wide utility of such plants. The narrowly specialized botanist is more than likely to be content with classifying the tropical trees and cataloguing their growth requirements. From whom, then, is to come the integration of knowledge that might bring these "mere facts" into a meaningful whole? J. Russell Smith,[13] an ecologically minded geographer, has led off with a powerful book on tree crops as a permanent agriculture. There is need for more men of breadth of approach and with synthetic, integrative minds to tackle this and similar problems. Might this not be a proper orientation for ecology?

Finally, such considerations as those above lead us to the discovery that we have made a significant and probably very dangerous change in our outlook on domestic plants. If we reason correctly, our present crops are the result of very long processes of plant modification which probably began quite unconsciously. Even the conscious modification of plants has been under way for great periods of time. Our domestic plants, where datable, first appeared in fully developed form about 5,000 years ago. At that time they were virtually as far from their possible wild ancestors as they are today. It seems likely, therefore, that by then they had already been long under human modification. A time for the beginning of the conscious propagation, selection, and modification of plants as early as ten or even fifteen thousand years ago does not seem unreasonable. And back of that time lies the immensely longer period of unconscious human influence upon plants, influence of the type suggested by the relationship between the California Indians and their grassland.

Our heritage from these successive ages has been a diverse assemblage of plants, each of which represents millennia of effort. Among noncommercial folk each variety is cherished for some special quality. The relationship between man and plant is felt to be very personal. Variety is considered good, and that one individual's beans may be different from those of his neighbor is thought right and natural. The result has been to establish a vast genetic reservoir filled with an almost infinite range of variations. Folk wisdom has thus maintained in its plant treasures the safeguard of diversity. Should blight strike any crop, someone would surely have a resistant strain.

We have drawn from this rich stock for all our commercial strains. Today we still send our plant explorers to "primitive peoples" to collect strains of plants with qualities of use to us. Everyone, indeed, should be familiar with the story and the significance of Acala cotton and Hopi Lima beans. The former, originated by Mexican peasant folk, has made possible our arid-land cotton agriculture. The latter, because of its nematode resistance, has saved the entire Lima-bean industry in California. The significance of such facts is that without a great diversity of crop material from which we may draw resistant or specialized varieties to meet future unforeseeable needs, we face imminent ruin.

What, then, are we doing to ward it off? We continue to standardize our crops, and as we draw the peasant folk of the world into our commercial orbit, we demand of them that they do likewise. The result, the abandonment of their characteristic crops by these simple folk, is a steady wasting of the varied heritage of the past. This is not visible to the economist and has not been discovered by many agronomists or botanists. It lies beyond the bounds of consideration by anthropologist or narrow specialist. Notwithstanding, it is a wastage of a basic resource that may be second only to the accelerated soil wastage of our times.

Is it not significant that the revelation of our dangerous course should spring from the integrative studies of workers in ecologically minded geographical schools, little restricted by traditional academic boundaries? Is not the field of man and his relations to his useful plants a field that needs and deserves the ecologist's attention? It is to be hoped that ecologists, in orienting themselves, will include this attractive field. One can also hope that the orientation of ecology will be outward, that it will welcome and encourage those men whose work falls between the narrowly defined academic disciplines.

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NOW I discovered that nothing is of such benefit to the human race as the discovery of and devotion to new truths and arts by which the life of men is cultivated . . . and above all if a man should bring forth no particular invention, even though quite useful, but were to kindle a light in nature which from its very beginning would illumine the confines which hold within their grasp facts already discovered, and once raised a lot would straightway lay open and bring into view the most hidden things, that man seemed to me to be the propagator of man's empire over the universe . . .

—Francis Bacon, Works VI, 446—50.