

## READING 3-1

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### Views on Agricultural Origins

#### Agriculture as Divine Gift

In the classical mythologies of all civilizations, agriculture is fundamentally of divine origin. It arrived in different ways from different deities and under various circumstances, but the underlying theme is recognizable. In the Mediterranean region, the source was a goddess: Isis in Egypt, Demeter in Greece, and Ceres in Rome. In China, it was the ox-headed god Shên-nung; in Mexico, Quetzalcoatl disguised as a plumed serpent or other animal. In Peru, perhaps Viracocha, perhaps the Inca sent by his Father the Sun, was responsible. The appearance of agriculture in mythology was almost always associated with other features of civilization: settled life, household arts, formal religion, and government by laws. We shall also see that agriculture brought death and gods that demanded sacrifice in exchange for rain and abundant harvests. The general features of these stories can be grasped from the selections that follow.

According to Diodorus Siculus (first century BC) agriculture originated in this way: five gods were born to Jupiter and Juno, among them Osiris and Isis. Osiris married his sister Isis and:

Did many things of service to the social life of man. Osiris was the first, they record, to make mankind give up cannibalism; for after Isis had discovered the fruit of both wheat and barley which grew wild all over the land along with other plants but was still unknown to man, and Osiris had also devised the cultivation of these fruits, all men were glad to change their food, both because of the pleasing nature of the newly-discovered grains and because it seemed to their advantage to refrain from their butchery of one another. As proof of the discovery of these fruits they offer the following ancient custom which they still observe; Even yet at harvest time the people make a dedication to the first heads of the grain to be cut, and standing beside the sheaf beat themselves and call upon Isis, by this act rendering honor to the goddess for the fruits which she discovered, at the season when she first did this. Moreover, in some cities, during the festival of Isis as well, stalks of wheat and barley are carried among the other objects in the procession, as a memorial of what the goddess so ingeniously discovered at the beginning. Isis also established laws, they say, in accordance with which the people regularly dispense justice to one another and are led to refrain through fear of punishment from illegal violence and insolence; and it is for this reason also that the early Greeks gave Demeter the name Thesmophorus, that is lawgiver, acknowledging in this way that she had first established their laws.

translation, 1946 C.H. Oldfather

It was Demeter who taught Tritolemos...”to yoke oxen and to till the soil and gave him the first grains to sow. In the rich plains about Eleusis he reaped the first harvest of grain ever grown, and there, too, he built the earliest threshing floor...In a cart given him by Demeter and drawn by winged dragons he flew from land to land scattering seed for the use of men...” (Fox, 1916).

Half a world away, we find a myth containing exactly the same elements: (i) people without agriculture are savages who live like animals and eat each other; (ii) through some divine instruction they not only learn how to produce food, but also to live by laws and to practice religion and those household arts common to civilized life.

From the Royal Commentaries of the Inca Garcilaso de la Vega (1961) we read:

Know then that, at one time, all the land you see about you was nothing but mountains and desolate cliffs. The people lived like wild beasts, with neither order nor religion, neither villages nor houses, neither fields nor clothing, for they had no knowledge of either wool or cotton. Brought together haphazardly in groups of two or three, they lived in grottoes and caves and like wild game, fed upon grass and roots, wild fruits, and even human flesh. They covered their nakedness with

the bark and leaves of trees, or with the skins of animals. Some even went unclothed. And as for women, they possessed none who were recognized as their very own.

Seeing the condition they were in, our father the Sun was ashamed for them, and he decided to send one of his sons and one of his daughters from heaven to earth, in order that they might teach men to adore him and acknowledge him as their god; to obey his laws and precepts as every reasonable creature must do; to build houses and assemble together in villages; to till the soil, sow the seed, raise animals, and enjoy the fruits of their labors like human beings.

The Inca king and queen arrived from heaven and were given a sign by which they would know where to establish a capital city. The place was located (Cuzco) and they set out to teach the savages “how to live, how to clothe and feed themselves like men, instead of like animals”. The epic continues (from Garcilaso de la Vega, 1961 edition):

While peopling the city, our Inca taught the male Indians the tasks that were to be theirs, such as selecting seeds and tilling the soil. He taught them how to make hoes, how to irrigate their fields by means of canals that connected natural streams, and even to make these same shoes that we wear today. The queen, meanwhile, was teaching the women how to spin and weave wool and cotton, how to make clothing as well as other domestic tasks.

In short, our sovereigns, the Inca king, who was master of men, and Queen Coya, who was mistress of the women taught their subjects everything that had to do with human living.

The basic theme is repeated with regularity around the world. From cuneiform tablets, we learn that the source of agriculture for the Babylonians, Chaldeans, and Phoenicians was a god named Oannes who appeared to the inhabitants of the Persian Gulf Coast and instructed them on growing crops and raising animals (Fiore, 1965). According to Maurice (1795):

He also taught men to associate in cities, and to erect temples to the gods, he initiated them in the principles of legislation, and the elements of geometry. He showed them how to practice botany and husbandry; and he reformed and civilized the first rude and barbarous race of mortals.

In Chinese mythology, P’an Ku separated the heavens and the earth, created the sun, moon, and stars, and produced the plants and animals. There followed 12 (or 13) celestial sovereigns, all brothers, who ruled 18 000 yr each, then 11 terrestrial sovereigns, all brothers, who ruled 18 000 yr each. After that came 9 human rulers, all brothers, who governed a total of 45 600 yr. Among these was Shên-nung, who taught the people agriculture and developed medicine. In another version, 16 rulers came after the 9 and these were then followed by the “Tree Sovereigns”, one of whom was Shên-nung. There are many variations of this particular theme (Christie, 1983; Latourette, 1941; Fitzgerald, 1950), including the following description of Shên-nung by the ancient Chinese historian Se-me-Tsien (first century BC). Shên-nung, he said, had the body of a man and the head of an ox, and his element was fire. He taught the people to use the hoe and the plow and initiated the sacrifice at the end of the year. He also found drug plants that cured and made a five-stringed lute (Chavannes, 1967).

In later Chinese history, Shên-nung is considered to have been an emperor, and a fictitious date (usually about 2800 BC) was assigned to his reign. He is said to have instituted the custom of ritually sowing five kinds of grains at the time of spring planting. The custom was preserved as late as the 20th century and the emperor himself participated in the ceremony. Actually, there is no evidence that there ever was a ruler by that name and the date is far earlier than any real date recorded in Chinese history.

The ancient legends have been amplified over the centuries and a veneer of embellishment has been added to the classical myths. The date given to Shên-nung is nonsense, but the myth of divine origin of agriculture is typical.

The mythologies of the American Indians are enormously varied and complex, but here I shall only present themes of the Aztec and Maya to compare with the Incan myth already cited. In the Aztec creation

literature, Quetzalcoatl was described as (from Prescott, 1936):

God of the air, a divinity who, during his residence on earth, instructed the natives in the use of metals, in agriculture, and in the arts of government...Under him, the earth teemed with fruits and flowers, without the pains of culture. An ear of Indian corn was as much as a single man could carry. The cotton, as it grew, took, of its own accord, the rich dyes of human art. The air was filled with intoxicating perfumes and the sweet melody of birds. In short, these were the halcyon days, which find a place in the mythic systems of so many nations in the Old World. It was the golden age of Anahuac.

Interestingly enough, both the Aztec and the Maya thought that maize (*Zea mays* L.) was on earth before mortal men. In the Aztec story, Quetzalcoatl disguised himself as a black ant, stole the cereal from Tonacatepel, and took it to Tamoanchin for the benefit of man. In the Mayan creation myth, the flesh of man was actually formed out of maize meal and snake's blood (Recinos, 1947). It is little wonder that the maize plant is venerated to this day in Mexico and Guatemala. The Mayan epic also contains oblique references to a garden of Eden or golden age in which nature yielded abundantly of its own accord.

In this manner they were filled with pleasure because they had discovered a lovely land full of delights, abundant in yellow ears and white ears (of maize) and also abundant in (two kinds of) cacao and innumerable fruits of mamey, chirimoya, jocote, nance, white zopote, and honey. (These fruits were thought to be: *Lucuma mammosa*, *Annona cherimolia*, *Spondias purpurea*, *Byrsonima crassifolia*, and *Casimiroa edulis*, respectively.) The foods of Paxil y Cayalá were abundant and delicious.

Popol Vuh pt. III, as reported in Recinos, 1947; my translation

In all the myths and tales mentioned so far, and many like them, the knowledge of agriculture is gratefully received as a blessing from the gods. The outstanding exception is found in Genesis where agriculture comes as a curse:

3:17...cursed is the ground for thy sake; in sorrow shalt thou eat of it all the days of thy life; 3:18 Thorns also and thistles shall it bring forth to thee; and thou shalt eat the herb of the field; 3:19 In the sweat of thy face shalt thou eat bread, till thou return unto the ground; for out of it wast thou taken: for dust thou art, and unto dust shalt thou return.

3:22 And the Lord God said, Behold, the man is become as one of us, to know good and evil: and now, lest he put forth his hand, and take also of the tree of life, and eat, and live for ever: 3:23 Therefore the Lord God sent him forth from the Garden of Eden, to till the ground from whence he was taken.

King James Version

There is no need to comment on all the various mythologies of agricultural peoples, but lest one be tempted to make too much of the similarities and underlying themes, I must point out that the Australian Aborigines, who did not practice agriculture, also had their mythologies and creation stories in which gods taught the people how to gather foods. An elderly Aborigine woman recited this part of the creation legend (as reported by Berndt and Berndt, 1970):

Ngalgulg [a mythical woman] gave us women the digging stick and the basket we hang from our foreheads, and Gulubar Kangaroo gave men the spear-thrower. But that Snake that we call Gagag [Mother's mother]-taught us how to dig for food and how to eat it, good foods and bitter foods.

Except for Genesis, the stories of agriculture as divine gift support the stereotype described in the previous chapter. The consensus of agricultural people is that:

1. There was a time before agriculture when people gathered their food from the wild.
2. Not farming is primitive, wild, uncivilized, lawless, graceless, and brutish.

3. Nonfarmers did not farm because of ignorance or lack of intelligence.
4. A god or a goddess was required to enlighten them as to agricultural practices as well as laws, arts, religion, and civilized behavior.
5. Agricultural man knew himself to be superior to hunter-gatherers.

While the fallacy of all this is demonstrable, this way of thinking has persisted to the present time and has colored modern concepts of agricultural origins. For example, it has been argued that vegetatively reproduced crops must be older than seed crops because it would be easier to think of; it would not occur to the savage mind that seeds could be planted. Another product of this way of thinking is the idea that it could have happened only once or twice at most. If we can rid ourselves of the stereotype, more possibilities open up.

### **Domestication for Religious Reasons**

About 1900, Eduard Hahn (1896, 1909) proposed a theory that some animals might have been first domesticated out of religious concern rather than for economic reasons. He chose the urus (*Bos taurus*), a form of wild cattle, as his model, but the idea was extended to other animals and tentatively to plants (Anderson, 1954). The idea has not dominated anthropological thinking but continues to be revived from time to time and appears in current anthropological and geographical literature (Isaac, 1970). The possibilities are intriguing and the theory should be considered on its merits.

Hahn argued that it would have been impossible to predict the usefulness of domestic cattle before they were actually domesticated. Wild cattle are large and fierce beasts and no one could have foreseen their utility for labor or milk until they were tamed. What motivated man to take the initial steps? They were domesticated, argued Hahn, for ritual sacrifice in connection with lunar goddess cults, for the great curving horns of the urus were crescent shaped. We know that people from western Europe to India have long held special religious feelings about cattle.

Even during the Ice Age, cattle were featured in the cave art of southwestern France and northeastern Spain. The great hall of the bulls at Lascaux is eloquent testimony to the concern for wild cattle. The archaeological site of Catal Hüyük in Turkey, dating back into the seventh millennium BC, reveals a series of altars, one above the other, each featuring cattle heads. The animals are also depicted in painted murals on the temple walls. Much later, we find elegantly painted bull-vaulting scenes on the walls of temples at Knossos, Crete. Cattle were sacred to the Egyptians, were sacrificed by the Romans, and are still considered holy by the Hindus of India.

Indeed, to this day, we find a “bull belt” extending from Spain and Portugal to eastern India in which people have a special religious feeling about cattle. At the western end of this region, animals are publicly and ceremoniously slaughtered before thousands at the bullfight rituals, usually on Sundays. At the eastern end of the belt, naked Sadhus lead riots in favor of antislaughter laws that would protect cattle, and in the southern portion, deep into the Sahara and beyond, cattle-herding tribes have special, mystical attachments between man and beast.

Or, consider the mithan. This is another form of *Bos* (the taxonomy varies according to taxonomist) thought to have been domesticated from the wild gaur of India. Mithan are kept by hill tribes from Upper Burma westward across Assam, the Naga Hills, and into Bhutan. They are not herded, but allowed to range in the woods and meadows. They are, however, individually owned and fairly tame. They are not used for transportation, draft, or milk, but are raised for prestige, wealth, and sacrifice only. Mithan are used to purchase land and pay bride prices, fines, and ransoms. They are sacrificed at certain special religious observances, and sometimes, as a show of wealth. A rich man may sacrifice a number of animals in front of a rival's house to display wealth or humiliate an enemy. The animals are left where they are killed and others come and take away the remains to eat. Mithan are eaten, but only after ritual sacrifice. Skulls and horns are used to decorate temples, houses, and graves.

In parts of Asia, chickens are raised, but neither the flesh nor the eggs are eaten. The birds are used

for sacrifice, divination by examining the entrails, or cock fighting. Chickens are thought to have been domesticated from the jungle fowl of southern and southeastern Asia. The art of divination from sacrificed birds seems to have spread with chicken raising at least into the Mediterranean area and was practiced by the ancient Greeks. The practice of rearing for sacrifice but not eating flesh or eggs has also been found in parts of the Americas and has led Sauer (1952), Carter (1971), and others to postulate early trans-Pacific contacts between the hemispheres.

Sheep, goats, pigs, and pigeons were sacrificed in the ancient world of classical times and it has been suggested that these also may have been domesticated to have a supply of sacrificial animals. From the above examples of legends and myths and from other clues, it seems at least plausible that animals may have been used in ritual killings as a substitute for humans. Human sacrifice and ritual killing may have been very ancient customs.

We know that there are a number of plants, wild and cultivated, that are used for ritual, ceremonial, and magical purposes. Some are drug plants, some produce dyes, and some have colorful leaves or flowers. I know of one plant of the West African forests which has a metallic, iridescent glint to the leaves and is used to mark the sites of secret (Poro) society meetings in the jungle. Anderson (1954) nominated the amaranths as candidates for ritual domestication. The blood-red inflorescences were used in religious ceremonies of ancient South America and I have seen them displayed over doorways in India and Pakistan. The pigment from another species is used in Hindu rituals. The Aztecs, among others used the grain in their rituals of human sacrifice, consuming popped seed in human blood.

Many narcotic and hallucinogenic plants have been used in religious ceremony and ritual. This, of course, does not mean that drug and ritual plants were domesticated before food plants, but it would not be wise in dealing with human affairs to ignore the motivations of religious concern.

### **Domestication by Crowding**

Some decades ago, V. Gordon Childe proposed what came to be known as the “propinquity theory”. Childe was a social-minded historian and pre-historian who was impressed by the evidence that the climates of North Africa and parts of the Near East had become increasingly desiccated over a period of several millennia BC. He visualized the rangelands drying up, forcing herd animals and man as well to withdraw to the banks of the few perennial rivers and to the oases where water could be found year-round. This brought man and animal into more intimate contact than had previously been the case and eventually induced man to domesticate some animal species (Childe, 1952).

In those days, many people still thought that man went through a set, three-phase development. He was first a hunter, then a herder, then a cultivator. The idea goes back to Greco-Roman times and still persists in some quarters. Having become a herder it was not difficult to pass to the next phase. The disturbance of the soil and vegetation by livestock at camp sites, together with manuring, would encourage weedy plants to grow. It was just such weeds that were said to be first taken into the domestic fold, and it was a short step from gathering them from the sheepfold to sowing them on purpose.

Childe (1925) also elaborated on what he called the “Neolithic revolution”, i.e., the shift from hunting and gathering to food production. He saw this as a radical and fundamental transformation of human adaptation and the most important development since the discovery of fire. The concept of an agricultural revolution has had more success than the oasis theory of domestication. The latter, however, was instrumental in stimulating a considerable amount of archaeological research because it was, to some degree, testable. Most of the testing was stimulated by the work of Robert J. Braidwood (1972) who set out to obtain archaeological evidence for the evolution of food production in the Near East. Many archaeologists have followed his example and there is now a large body of evidence on the subject. The evidence does not bear out the propinquity theory very well, but climate has changed and has altered the available food supplies and those changes must be taken into consideration.

### **Agriculture as Discovery**



The most extensively developed model for agricultural origins is that cultivation was an invention or discovery. Because Darwin's theory of evolution has had profound influence on modern biology and anthropology, it is interesting to see how he viewed the subject (Darwin, 1896):

The savage inhabitants of each land, having found out by many and hard trials what plants were useful, or could be rendered useful by various cooking processes, would after a time take the first step in cultivation by planting them near their usual abodes...The next step in cultivation, and this would require but little forethought, would be to sow the seeds of useful plants; and as the soil near the hovels of natives would often be in some degree manured, improved varieties would sooner or later arise. Or a wild and unusually good variety of a native plant might attract the attention of some wise old savage; and he would transplant it, or sow its seed.

Darwin, among others, was convinced that nomadic people could not develop agriculture (Darwin, 1909):

Nomadic habits, whether over wide plains, or through the dense forests of the tropics, or along the shores of the sea, have in every case been highly detrimental (to "progress"). Whilst observing the barbarous inhabitants of Tierra del Fuego, it struck me that the possession of some property, a fixed abode, and the union of many families under a chief, were the indispensable requisites for civilization. Such habits almost necessitate the cultivation of the ground; and the first steps in cultivation would probably result, as I have shown elsewhere (above), from some such accident as the seeds of a fruit tree falling on a heap of refuse, and producing an unusually fine variety.

Darwin (1909) concluded, however, that "the problem, of the first advance of savages towards civilization is at present much too difficult to be solved".

Elaborations on the theme developed the "happy accident" or "Eureka!" theory of plant domestication. No motive is required, only the brilliant revelation that seeds can be sown to produce plants when and where desired. The advantages of producing food on purpose are so obvious that all that was needed was the concept and then the development of agriculture was assured.

There are several ideas in the Darwinian view that should be separated for clarity: (i) man must be sedentary before he can cultivate plants; (ii) useful plants are most likely to be discovered in manured refuse heaps; (iii) useful plants are likely to be first planted in dump heaps; and (iv) a wise old savage is required to start the process.

These concepts seem reasonable enough and have provided the basis for several theoretical treatments of the subject. One of the most influential was that of Carl O. Sauer (1952), a geographer whose *Agricultural Origins and Dispersals* has become a classic. He combined the Darwinian views with Eduard Hahn's idea (1896, 1909) that vegetative propagation should precede seed agriculture, and set out to locate the cradle of agriculture on theoretical grounds. He listed six presuppositions as a basis for his search (here condensed):

1. Agriculture did not originate from a growing or chronic shortage of food. People living in the shadow of famine do not have the means or time to undertake the slow and leisurely steps out of which a better and different food supply is to develop in a somewhat distant future...
2. The hearths of domestication are to be sought in areas of marked diversity of plants and animals... This implies well-diversified terrain and perhaps also variety of climate.
3. Primitive cultivators could not establish themselves in large river valleys subject to lengthy floods and requiring protective dams, drainage, or irrigation...
4. Agriculture began in wooded lands. Primitive cultivators could readily open spaces for planting by deadening trees; they could not dig in sod or eradicate vigorous stoloniferous grasses....
5. The inventors of agriculture had previously acquired special skills in other directions that predisposed them to agricultural experiments...
6. Above all, the founders of agriculture were sedentary folk.

The sedentary life, he thought, could best be developed by fishing tribes, and for his purpose he sought

them on fresh waters in a mild climate. Fresh water was selected because seaside vegetation has contributed relatively little to agriculture and what has been developed has come late in crop evolution. With these presuppositions in mind, he proposed Southeast Asia as the oldest hearth of agriculture. From there, systems spread northward into China and westward across India and the Near East, into Africa and the Mediterranean region, and finally into northern and western Europe. In the Americas, he located the original hearth in the northwestern part of South America from whence agriculture spread northward into Mexico, then to eastern North America, southward along the Andean chain, eastward to the Atlantic coast of Brazil, and to the Caribbean island chain. He left open the possibility that civilization might have been transmitted from the Old World to the New World.

Southeast Asia was selected because most anthropologists have felt that agriculture is older in Asia than in the Americas and because that region fits most of his presuppositions best. In particular it had a mild climate and varied terrain, and was rich in fresh water aquatic resources as well as edible plants. People could settle down in permanent villages and develop the arts of cultivation without the pressures of periodic scarcity. The fact that a different set of plants was domesticated everywhere did not bother him. It was the idea of cultivation that diffused and that once people were shown the obvious superiority of the system, they would begin to domesticate plants from their own flora even if the rewards were to be found in the distant future.

Edgar Anderson (1954) liked Sauer's view and added some genetic threads to the fabric. He saw weeds as potential domesticates; he also thought that an increase in hybridization, with disturbed habitats, could result in increased variation and new genetic combinations from which useful selections could be made:

Rivers are weed breeders; so is man, and many of the plants which follow us about have the look of belonging originally on gravel bars or mud-banks. If we now reconsider the kitchen maddens of our sedentary fisherfolk, it seems that they would be a natural place where some of the aggressive plants from the riverbanks might find a home, where seeds and fruits brought back from up the hill or down the river might sometimes sprout and to which even more rarely would be brought seeds from across the lake or from another island. Species which had never intermingled might do so there, and the open habitat of the rubbish-heap would be a more likely niche in which strange new mongrels could survive than any which had been there before man came along.

Anderson also felt that agriculture began in the tropics on dump heaps and that vegetative propagation predominated at the beginning, but he also left open the question of early transoceanic contact.

Evidence accumulated since the Sauer-Anderson models were suggested has indicated that some of their presuppositions were incorrect. For example, sedentary life is not essential to the evolution of agriculture. In Mesoamerica there is good archaeological evidence that the people remained nomadic long after they were purposely growing plants for food (Flannery, 1968, 1986). In the Near East, there is evidence that a nuclear center developed in an area not in the tropics and by people not necessarily dependent upon aquatic resources. In that region, the people most dependent upon fishing and fowling, the Natufians, were among the last to take up agriculture. Thus, although the Sauer-Anderson models have been widely accepted by many, they are open to question.

### **Agriculture by Stress**

A number of investigators have been persuaded that agriculture was adopted as a result of stress brought on by an increase in population and depletion of the foraging ranges. Mark N. Cohen is the most prominent of this school and he developed the argument at book length in his *The Food Crisis In Prehistory* (1977). He found archaeological evidence for depletion of local resources in the change of diet from preferred foods to those less preferred and less nutritious and in the exploitation of resources not used or little used in earlier times. These newer resources may also come from greater distances from sites excavated. The argument that present or recent hunter-gatherers keep the population well below the carrying capacity is countered by the argument that recent hunter-gatherers are not typical of pre-agricultural people. Those who could manage population size could remain hunter-gatherers; those who did not became farmers.

Later, Cohen and G.J. Armelagos organized a symposium on the paleopathology of people at the time when agriculture was being adopted in various places around the world (Cohen and Armelagos, 1984). The reports in the symposium present some fascinating glimpses of the health status of ancient people. On the whole, they did not provide evidence for a decline in health before the adoption of agriculture, but there was a clear consensus that early farmers were not as healthy as pre-agricultural people. In general, the people of upper Paleolithic were taller, had excellent health, and no evidence of endemic disease.

In the eastern Mediterranean, there was a sudden drop in stature and evidence of some anemia and malaria during the Mesolithic. Presumably the rise in sea level resulted in more marshes and mosquitoes and an increase in population density favored the virulent *Plasmodium falciparum*. The diet, however, appeared good (Angel, 1984).

The nutritional health of Neolithic people in that region was low and remained low for about 5000 yr until a major improvement in classic times (650-33 BC). The decline was progressive, not sudden, and there was no evidence to suggest that man was forced into agriculture by a decline in diet. While irrelevant to agricultural origins, J.L. Angel's data on teeth are instructive. Using number of lesions per mouth, i.e. caries, abscess, and loss, he reported the following: Paleolithic 2.3; Mesolithic 1.3; Neolithic 2.6-3.5; Bronze 5.0-6.7; Iron 6.8; Classic 4.1; then fluctuating from 5.2 to 6.6 until the 19th century (except 3.4 in Byzantine times). In the 19th century lesions per mouth jumped to 12.3 and the modern USA white population has nearly 16! Sugar has become cheap and abundant (Angel, 1984). We have, however, recovered the height we lost at the end of the Pleistocene, and a little more.

### **Agriculture as an Extension of Gathering**

In Chapter 1 it became clear that hunter-gatherers have long known all they needed to know to develop agriculture. They did not need to discover the concepts of planting; they already had them. We have asked, "Why farm?" We could also ask the question, "Why not farm if you are equipped with all the materials and information to do so?" One approach is to ask a gatherer. During his study of the Bushmen, Richard Lee did exactly that, and he received the celebrated reply, "Why should I farm when there are so many mon-gongo nuts?" (Lee and DeVore, 1968). The Aborigines put it in almost the same terms (Berndt and Berndt, 1970):

You people go to all that trouble, working and planting seeds, but we don't have to do that. All these things are there for us; the Ancestral Beings left them for us. In the end, you depend on the sun and the rain just the same as we do, but the difference is that we just have to go and collect the food when it is ripe. We don't have all this other trouble.

Perhaps, even more to the point, an informant told A.K. Chase: "It is not our way; it is alright for other people. We get our food from the bush." (Chase, 1989). It is a question of what is perceived to be right and proper. We now have some data to show that the Aboriginal opinion has merit. In 1965, Esther Bosrup published a work entitled, *The Conditions of Agricultural Growth* that stimulated a number of studies on the input and output of energy in various systems. She showed that, on the whole, increasing energy inputs results in a decrease of output per amount of energy put into the system. David Pimentel and his co-workers at Cornell University have followed with a long series of reports and a recent review summarizes much of the work in this field (Pimentel and Hall, 1989). An important study by Black (1971) could also be cited. The most efficient agricultural systems use human labor only. For cassava in Zaire and Tonga, returns in kcal per kcal invested were 37.5 and 26.9, respectively. For sorghum in Sudan and maize in Mexico, returns were 14.1 and 10.1, respectively. Using draft animals returns were 3.3 for rice in Philippines, 3.4 for maize in Mexico, -0.5 for wheat in India, and -0.1 for sorghum in Nigeria. With high mechanization, figures for the USA are approximately 2.5 for maize, 1.4 for rice, 1.8 for wheat, and 2.3 for potato (Pimentel, 1974). Data from hunter-gatherers are confounded by different methods of calculation, but some results indicate returns comparable to or higher than the most efficient agricultural systems. My wild wheat harvest in Turkey yielded 40-50 kcal per kcal expended (Evans, 1975). The Biblical view of agriculture as a curse has



support from these studies.

More studies and better data are needed, but we have ample anthropological and ethnographical evidence to show that increasing the food supply through cultivation means an increase in work. In general, the more intensive the agricultural system, the more work is required for a unit of food. Thus, if we are to understand the origins of agriculture, we must visualize situations in which man is willing to expend more energy to obtain food. In this respect, farming is not so attractive that gatherers are likely to take it up on sight or on first contact. Some rather compelling reasons would seem to be required.

In pre-agricultural times the human population was not regulated by the food supply. If this were the case, Binford (1968) has pointed out that two corollaries would follow: "1) Man would be continually seeking means of increasing his food supply," and "2) It is only when man is freed from preoccupation with the food quest that he has time to elaborate culture." From what we have seen, both are patently false. Populations of hunter-gatherers are regulated well below the carrying capacity of the range, and the environment does not exert pressure on man to change his food procurement systems. Neither agricultural nor industrial man has anything like the leisure time of hunters and gatherers. Therefore, we must look elsewhere for the motivation to carry on agriculture.

What, then, might generate the motives that caused man to domesticate plants (and animals)? A much-cited model in current literature is one based on proposals put forth by Lewis Binford (1968) and Kent Flannery (1968). It attempts to integrate ethnographic and archaeological information and suggests not only reasons for but places where the initiative toward food production might have been taken. Explicit in the Binford-Flannery model is the recognition that gatherers are sophisticated, applied botanists who know their materials and how to exploit them. They are prepared to grow plants if and when they think it would be worth the effort. Furthermore, the differences between intensive gathering and cultivation is minimal; recall the square kilometers of Australian landscape pitted by Aborigines digging yams.

Binford, in particular, emphasized the fact that one of the general post Pleistocene adaptations of man was a fuller exploitation of aquatic resources. This is one of the most characteristic features of the so-called "Mesolithic" wherever it can be identified. Canoes, boats, and rafts were developed, and there was a great proliferation of archaeological sites that suggested fairly permanent residence and subsistence by fishing, fowling, and gathering. The sedentary fisherfolk referred to by Sauer and Anderson did appear in many parts of the world; however, Binford suggests that it was not they who began domestication, but groups that budded off from them and migrated into regions already occupied by hunter-gatherers. The argument goes that long before there was a food resource crisis among the fisherfolk, groups would move out and migrate into less well-endowed regions and ecological zones. The fisherfolk population remained stable, but the migrants precipitated a crisis along the interface between the sedentary peoples and the nomadic hunter-gatherers. It was in response to this crisis that people were willing to go to the effort of cultivation.

The Binford model was spelled out in sufficient detail that he could make some predictions to be tested:

1. The initial activities of domestication in the Near East will appear adjacent to areas occupied by sedentary forager-fisherfolk (evidence for this was fairly firm at the time of the prediction).
2. Evidence of independent domestications will be found in European Russia and south-central Europe (suggestions are coming in that this may be true, e.g., Lisitsina, 1984).
3. Evidence of similar events will be found widely separated over Europe, Asia, and the Americas. (See Smith (1989) and Ford (1981) for reviews of early gardening in the Midwest USA.) Flannery has provided some evidence from Mesoamerica and the African evidence is compatible with the prediction.

There may be biological and ecological reasons as well for proposing that cultivation would begin adjacent to the best foraging ranges rather than in them. In the Near East massive stands of wild wheat's cover many square kilometers. Harlan and Zohary (1966) have asked, "Why should anyone cultivate a cereal where natural stands are as dense as a cultivated field? If wild cereal grasses can be harvested in unlimited

quantities, why should anyone bother to till the soil and plant the seed?" The same arguments could well apply to the African savanna or to California, where wild food resources were abundant.

A major implication of the model is that the activities of plant domestication are likely to have taken place independently and probably simultaneously in many areas all over the world. The space-time pattern that would emerge would be almost the opposite of that of the Sauer-Anderson model. It would appear that the differences are testable by archaeological means and that even botanical and genetical evidence could come to bear on the problem.

I have been using the term "diffuse origins" for over 36 yr (Harlan, 1956, 1961, 1980, 1986). The term can apply to individual crops as well as to agricultural systems. Individual crops have origins that are diffuse in time and space in the sense that they evolve over time as they spread into new regions. At the beginning of domestication, they are like the wild forms, but the end products may be enormously modified and found far from the original source or sources. Agriculture as a food-producing system is diffuse in the sense that we will not and cannot find a time or a place where it originated. We will not and cannot because it did not happen that way. Agriculture is not the result of a happening. It is not due to an idea, a discovery, an invention, a revelation, nor even a goddess. It is the end product of a long period of adaptive co-evolution. The processes sometimes took millennia and were often spread over regions some thousands of kilometers across.

### **Domestication by Perception**

A problem I have with the current theories about reasons for taking up farming is that they are all proposed by 20th century, university educated, middle-class pragmatists all looking for some golden bottom line that would explain it all. Labor and time inputs, optimum foraging strategies and so on are abstractions of the modern mind-set and world view. Could we come nearer to an understanding if we attempted to approach the mind-set and perceptions of the people who actually set the processes of domestication in motion? It seems to me that we might obtain some clues from perceptions of surviving hunter-gatherers and from folklore of subsistence farmers.

I have mentioned the perception of Aborigines that a landscape left unburned for a number of years was, somehow, uncomfortable and inhabited by demons and malevolent spirits and was spiritually dangerous (Chase, 1989). Farmers in Amazonia have a similar perception of safe and dangerous space. To them, the forest is dangerous and full of demons and evil spirits; the house garden is safe and even protected by invisible Harpy eagles (Reichel-Dolmatoff, 1971). The fields that produce most of the food for a village and migrate through the jungle year-by-year in a bush fallow rotation are perceived as intermediate in spiritual safety. The Kuruk and other tribes of western North America who grew tobacco and procured their food by hunting and gathering also had concepts of safe and dangerous spaces. They were afraid of wild tobacco because it might have sprouted on the grave of someone and contain malevolent spirits. They grew their own ceremonial tobacco in a safe space. It is easy to see how such perceptions would lead to gardening.

The perception of an association between plants like tobacco and the grave has a remarkable distribution. Consider the following folktales:

"A mother who lost her only daughter spent her days weeping at her grave. One day a strange plant sprouted from the grave. It grew taller and taller before her eyes. It was not good to eat after boiling it, roasting it or steaming it..." She tried smoking it and it comforted her. (Mayer, 1986, p. 278). This is the origin of tobacco in Japan.

In China, opium appeared on the grave of a wife who had been mistreated by her husband. When the husband was near death, she appeared to him in a dream and told him how to gather the latex and smoke it. He did as he was told and was comforted and cured of his illness-temporarily; if he did not smoke every day, he fell ill again to the point of near death (Eberhard, 1965). This explains addiction as well as origin of the crop.

In the Gran Chaco of South America, we are told: A cannibal woman is killed by a culture hero and from the ashes the first tobacco grows (Wilbert, 1987, p. 151). A similar story is told about coca in South

America and about the betel palm and the betel leaf in Southeast Asia and South Pacific.

Among the Fang of Gabon in Africa, *Tabernanthe iboga* is an important hallucinogen used in certain rituals and initiation ceremonies. The alkaloid, ibogaine, is extracted from the bark of the roots and is sufficiently potent that an occasional initiate is lost by overdose. It is said that a creator god killed a pygmy and cut off his fingers and toes which he planted and from the digits came this powerful plant (Dorson, 1972).

But all these folktales about psychedelic plants belong to a larger family of stories concerning origins of food plants and of agriculture itself. Here is one from the Japanese Kojiki compiled in 712 AD (Mabuchi, 1964, p. 3).

A heavenly god asked an earthly goddess for a meal. Having seen her cooking various kinds of food taken out of her mouth, nose and anus, the heavenly god killed her in anger. Shortly afterward there appeared seeds of various crops from her corpse; from her eyes rice, from her ears the "millet", from her nose the red bean, from her anus the soya bean, from her vagina barley, while the silk worm came out of her head.

The tale is open-ended; for example, after maize was imported it was added and was said to come from the teeth which are in rows like maize kernels. The source of soybean suggests flatulence, and other parts of the body are suggestive as well. In similar stories the coconut comes from a human or monkey's head, bananas from fingers, and so on.

The following tale from New Guinea explains the origin of agriculture (Healey, 1988, p. 10):

A group of women lived alone in the grasslands. They had no gardens but ate game which they flushed from the grass by fire. One day a grass fire spread to the forest and burnt a *menjawai* forest demon in his lair in an epiphytic fern. After the fire had died down the women saw a column of smoke rising from the burnt forest. They went to investigate and found the smoking corpse of the demon. In fear they hurried back to their grasslands, but some months later they returned to find all manner of crops sprouting from the belly of the demon. They took and planted cuttings of the crops and experimented with various ways of preparing them before they discovered the proper ways to cook them.

There are hundreds of tales on the same theme with an essentially worldwide distribution. Someone or something must die for crops to appear and grow. In many tales death came for the first time with agriculture. As Mabuchi put it, "From the one who died the primordial death, there originated food plants, while human beings became mortal by this event. By repeating ritually such a primordial act, the fertility of both plants and human beings is to be secured. With this view are closely interrelated the human sacrifice, head-hunting, cannibalism, the ritual death in initiation ceremony and so on, death, killing, procreation and reproduction forming an inseparable unit." (Mabuchi, 1964, p. 85)

The crops of the Aztec were irrigated by human blood; thousands of victims were sacrificed yearly to appease the gods who controlled the weather and crop growth. The Phoenicians sacrificed their own children to Baal. This horrified the Hebrews who at some time substituted animals for humans, but the number of animals slaughtered is rather remarkable. From Leviticus 23 and Numbers 28-29 one can calculate a yearly requirement of 113 bulls, 37 rams, 1093 lambs, and 30 goats, by the priests alone. This does not include free will offerings, sin offerings, or guilt offerings volunteered by the people. By the time of Josephus, the number of rams required had increased to 118. The birth of agriculture was generally a bloody business.

The world-wide distribution of themes of origin tales tell us something of the perceptions and mind-set of the people who first took up the cultivation of plants and the taming of animals. These people lived in a world full of spirits, demons, and ogres. They did not view the world as we do and were not concerned with getting the most food for the least amount of effort or in the shortest possible time. Motivation was far more likely to have been in terms of what was perceived as spiritually safe and religiously comfortable. We do not know and never will know the perceptions of the Indians of Oaxaca who grew squashes (*Cucurbita* spp.) on a small scale in summer camp as they made their rounds as hunter-gatherers. Presumably, a wild

squash is not so menacing as wild tobacco, but wild squash is very bitter. The bitterness may have been perceived as some kind of plant “power” worthy of respect and consideration. We shall never know what they thought, but it seems certain that a few squash vines had very little if any effect on the economy of the Indians who grew them. The activity could hardly have affected the food supply significantly. If they were being forced into agriculture because of population pressure, they surely would not have taken 2000 yr to accomplish the job.

### **A No-Model Model**

Every model proposed so far for agricultural origins or plant domestication has generated evidence against it. It is possible that some plants and animals were domesticated for ritual, magic, ceremony, or religious sacrifice, but only a few out of hundreds of species could be so identified. It is likely that a few cultigens did originate from dump heap weeds, but many show no such inclination. Some crops were derived from weeds and some weeds were derived from crops, but by far the more usual pattern is the crop-weed complex in which both crop and weed are derived from the same progenitors. Some crops arose in the Vavilovian centers, and others did not; many have centers of diversity, but others do not. Some people were sedentary long before agriculture; others maintained a nomadic way of life long after plants were domesticated and agriculture was established. There is no model with universal, or even very wide application; yet most of them contribute, in some degree, to an understanding of the problem.

My own inclination is to recognize the fact that human beings are enormously varied and their motivations are always complex and never simple. It is difficult enough to psychoanalyze a living, speaking human, so how can we expect to analyze people who lived 10 000 yr ago and who belonged to cultures we can but dimly imagine? People do similar things for entirely different reasons and they find very different solutions to the same problems.

I am inclined to develop a no-model model which leaves room for whole arrays of motives, actions, practices, and evolutionary processes. What applies in Southeast Asia may not apply at all in Southwest Asia. The patterns in Africa may not be the same as the patterns in Mexico. A search for a single overriding cause for human behavior is likely to be frustrating and fruit-less. A humanistic no-model model simply recognizes the likelihood that no single model will explain agricultural origins.

Man did take the initiative in modifying his environment, and plants responded genetically to his activities. He deliberately changed the vegetation with set fires; he sowed seeds; he churned up square miles of land to get tubers, all without developing “agriculture.” The development of true agriculture would require more work, but few changes in techniques. It is not even necessary to assume a crisis was always responsible, for the motivations could have been many and various.

The most conspicuous difference between hunting-gathering economies and agricultural ones is in the size of the human populations that can be supported. Farming takes more work, but it can feed more people. Population pressures may or may not have initiated plant domestication, but they have certainly forced the evolution of agricultural economies in a single direction.

Generalizations about human behavior are always hazardous, but there does seem to be a significant difference between agricultural societies and the surviving hunter-gatherers in the role and importance of children. In the agricultural economies, children are an economic asset. They add to the labor force; they create wealth through dowries and bride-prices; and they provide security for the aged. In some societies today, the situation is so intense that childless couples become literally impoverished and may actually starve to death. Even survival sometimes depends upon having children, and the more the better.

The system tends to be self-defeating in the sense that there are strong forces always pressing toward larger populations. More people require more food. More food requires more intensive farming practices which in turn require more work per unit of food. The only way to get more work done is to increase the labor force by having more children. A high value is placed on prolific women and barren ones may be cast out of the society. Subsistence agriculture is not likely to reach equilibrium without external population controls such as disease epidemics, famine, and war.



How far we can push the disequilibrium back towards the beginning of agriculture has not yet been determined. The economic value of children may have been an important influence very early in the evolution of agricultural societies. Certainly, the steady and intense pressures for ever larger populations set into motion trends that are essentially irreversible. Living within the productive capacity of the environment becomes a continual and exhausting struggle. A “hungry time” becomes a part of every year while crop failure means starvation and death. The threat of famine has become a characteristic of agricultural systems; we have no evidence that this was a part of pre-agricultural systems.

On the other hand, the sample of surviving gatherers is so small and biased that our information may be misleading. The survivors maintain their populations at a fraction of the size that could be supported, but was this true of gatherers in the hearths of agriculture? Perhaps cultivation did begin because of population pressures and degradation of natural resources. How are we to know? Perhaps plant cultivation began in different areas for different reasons.

We have no more facts to support a no-model concept than any other theory, but it does have the advantage of being independent of any set of presuppositions. It is obvious that views of agricultural origins in the past have too often been based on assumptions that have either turned out to be altogether false or that have applied to one situation and not another. The no-model view takes into account the distinct possibility that plant domestication began in different regions for different reasons, and permits us to build theories on evidence as it accumulates rather than on preconceived notions.

The greatest difficulties in understanding agricultural origins trace to a want of information, and no amount of speculation can substitute for evidence. Although we have made some advances in the century since Darwin wrote that the problem was too difficult to be solved, we are still far from determining the motivation that brought about such a profound change in human adaptation.

### **Geography of Plant Domestication**

No consideration of agricultural origins would be complete without mention of Alphonse de Candolle and N.I. Vavilov. Although neither of them maintained elaborate theories about why or how agriculture originated, they were both concerned about the geography of plant domestication and crop origins.

de Candolle lived in Geneva and was one of the foremost botanists of the 19th century. His book, *Origin of Cultivated Plants* (reprinted in 1959), was primarily an academic and intellectual exercise. He was interested in geography of plants in general and wrote extensively on the subject. He attempted to locate the region of origin of a good many cultivated plants by any means he could. He investigated the distribution of wild relatives, history, names, linguistic derivatives, archaeology, variation patterns, and every other clue he could think of.

In many respects there was not a great deal known in de Candolle’s time. Archaeological plant remains were largely confined to materials from the Egyptian tombs and the Swiss lake dwellers. Wild races of a number of plants were not then known, and some of his information was faulty. Nevertheless, his book remains today a model of scholarship and continues to be a useful source of information about the origins of cultivated plants.

N.I. Vavilov was a Russian geneticist and agronomist in charge of an enormous National Institute of Plant Industry. At his disposal were dozens of experiment stations scattered over the Soviet Union, staffed with thousands of professional and sub-professional workers. He proposed one of the most dazzling and ambitious plant breeding programs ever attempted. It was his plan to collect and assemble all of the useful germplasm of all crops that had potential in the Soviet Union, to study and classify the material, and to utilize it in a national plant breeding effort. A vigorous, worldwide plant exploration program was launched, and for the first time a really systematic plan for genetic resource management was established.

Vavilov was interested in origins because he was interested in genetic diversity, and he thought the two were related. In 1926 he wrote an essay, dedicated to Alphonse de Candolle, *On the Origin of Cultivated Plants* (Vavilov, 1926) in which he proposed that one could reliably determine the center of origin of a crop by an analysis of patterns of variation. The geographic region in which one found the greatest genetic diver-



sity was the region of origin. This was especially true if much of the variation was controlled by dominant genes and if the region also contained wild races of the crop in question.

In this essay, he proposed eight centers of origin with some sub-centers, Fig. 1, and these are widely accepted even today. Actually much of the plant exploration conducted by his institute had yet to be done and analyses of previous expeditions had not been completed. The work was more of a literature review and expression of philosophical doctrine than a scientific paper based on research data. The techniques for measuring diversity in those days were based on old-fashioned elementary taxonomy. Later, he did develop a classification of agro-ecological groups using such traits as response to day length, cold requirements, reaction to disease, and general adaptation to specific environments.

While data to support his center of origin theory were not provided at the time, an enormous amount of information was generated by the Institute (now called the N.I. Vavilov Institute of Plant Industry or VIR), and published in the *Bulletin of Applied Botany and Plant Breeding* from about 1920 to 1940. These studies are old now, but when a student at the Crop Evolution Laboratory, University of Illinois, wished to study a crop, we always advised that he or she turn first to the VIR publications. "First, see what the Russians said about the crop and go on from there; that is the place to begin." The different crops were studied by professionals who knew their material well and had field experience with it. Many of these studies could not now be conducted because of recent changes in cultivar and landrace usage.

In recent years, several analyses of world collections or parts of world collections have been made and published, especially in wheat, rice, barley, maize and other major crops for which large collections are available. In some of these, as many as 40 isozyme loci were analyzed using electrophoresis. In others, flavonoids or seed storage proteins were studied, and most of them employed sophisticated computer programs to analyze the data. Molecular diversity of various DNA fractions is also beginning to be studied, although



**Fig. R 3-1.** The eight centers of origin, according to N.I. Vavilov (from Harlan, 1971; copyright © 1971 by the American Association for the Advancement of Science).

the methods are time consuming and expensive, compared to some of the other techniques. Discussion and references may be found in Brown et al. (ed.), *Plant Population Genetics, Breeding and Genetic Resources* (1990).

No modern study of diversity has confirmed the intuitive geographic patterns described by Vavilov. Some concentrations of diversity can be detected, to be sure, but they have little or nothing to do with origins. For example, Peeters (1988) used the Cambridge barley collection, recording 12 qualitative and 18 quantitative traits averaged over 3 yr, for more than 100,000 observations and concluded the greatest diversity in barley is in USA, followed by Turkey, Japan, USSR, and China. Afghanistan is 16th and Ethiopia 18th. There was no real center with geographic integrity. Other studies have given similar anomalous results.

Vavilov had to concede that his method of “differential phytogeography” did not work very well. He invented the concept of secondary centers to account for the fact that centers of diversity are not the same as centers of origin. In fact, the variation in secondary centers is often much greater than in the centers of actual domestication where these can be located on independent evidence. He also developed the concept of secondary crops; these are derived from weeds of older, primary crops. Rye and oats were cited as examples. As agriculture spread from the Near East and Mediterranean centers toward northern Europe, weed rye and weed oats were carried along as contaminants of the barley and emmer fields. In due course domesticated races developed, far removed from the original homeland of rye and oats. As we have seen, Edgar Anderson (1954) favored the idea that crops were often derived from weeds and was strongly influenced by Vavilov’s writings.

The concept of center of origin has evolved since Vavilov’s time. Basically, what Vavilov did was to draw lines around areas in which agriculture has been practiced for a very long time and in which indigenous civilizations arose. The geography of crop variation depends a lot upon the geography of human history.

When one actually analyzes origins crop by crop, it soon becomes apparent that many of them did not originate in Vavilovian centers. Some crops do not even have centers of diversity. The pattern is much more complex and diffuse than Vavilov had visualized. In the case of the Near East, we seem to have a definable center in the sense that a number of plants and animals were domesticated within a relatively small region and were diffused outward from the center. In Africa, nothing of the sort is apparent. The evidence seems to indicate that activities of plant domestication went on almost everywhere south of the Sahara and north of the equator from the Atlantic to the Indian Ocean. Such a vast region could hardly be called a “center” without distorting the meaning of the word, so I called it a non-center (Harlan, 1971). In North China, there seemed to be fairly convincing evidence for a center, but nothing of the sort is evident in Southeast Asia and the South Pacific. The pattern may be similar in the Americas with a center in Mesoamerica and a non-center in South America. My own version of agricultural origins is shown in Fig. 2.

I have proposed three independent systems, each with a center and a non-center. I also visualized some stimulation and feedback in terms of ideas, techniques, or materials between center and non-center within each system. Since making these proposals, my centers have been eroding by more information. The Near Eastern “center” is flanked by activities in the Caucasus (Lisitsina, 1984), possibly the Balkans and Ethiopia. For animal domestication, the Near Eastern “center” is flanked by domestication in Baluchistan, Europe, and Africa. The Chinese “center” has become much more diffuse than it once seemed. After the beginning of the Holocene, a mosaic of Mesolithic cultures evolved over most of China, and from these several Neolithic cultures developed (Chang, 1986). The pattern now appears to be a mosaic of developments over a broad front rather than one of a small, restricted center in which innovations occurred and out of which they were diffused. The Mesoamerican “center” is mosaiced by independent developments in the mid-Mississippi-lower Ohio watersheds (Smith, 1989), in Sonora, Arizona (Ford, 1981; 1985) and northeast Mexico. With respect to origins of agriculture, it is, perhaps, time to abandon the concept of centers of origin altogether. Individual crops may or may not have centers of origin and many have centers of diversity, but agriculture as a food-procurement system has no specific time or place of origin. In the geographic sections of the book to follow, I shall refer to regions rather than centers.

### An Ecological Approach

The geography of domestication might make more sense if we examined the ecological settings to see what conditions are most likely or most unlikely to be suitable for agricultural origins. This, of course, is what C.O. Sauer tried to do, but in this treatment, I shall make use of experience and hindsight. We may list the major climate or vegetation formations as:

- |                             |                        |
|-----------------------------|------------------------|
| 1. Tundra and taiga.        | 6. Tropical forest.    |
| 2. Temperate forests.       | 7. Tropical savanna.   |
| 3. Temperate prairies.      | 8. Deserts.            |
| 4. Temperate steppes.       | 9. Tropical highlands. |
| 5. Mediterranean woodlands. | 10. Sea coasts.        |

The tundra and taiga can easily be ruled out. To this day we have not been able to do much with them agriculturally. Reindeer were domesticated and some forestry is practiced, but there is little in the way of farming. The well-developed temperate prairies, Fig. 3, can be ruled out as being too difficult for primitive tools. They were not developed in North America nor in the Ukraine and Russia until special steel plows were invented to turn the sod. Some of our most productive soils could not be exploited until drainage was developed as well. Indians of the North American prairie region who practiced agriculture kept to wooded loess soils of river terraces and woodland bottoms and avoided the prairie proper. White settlers who followed did the same, moving from woodland to woodland and skipping the prairie because they could not manage the sod. The only major crop that might be ascribed to temperate prairie is sunflower (*Helianthus annuus*) and it was initially cultivated in adjacent woodlands.

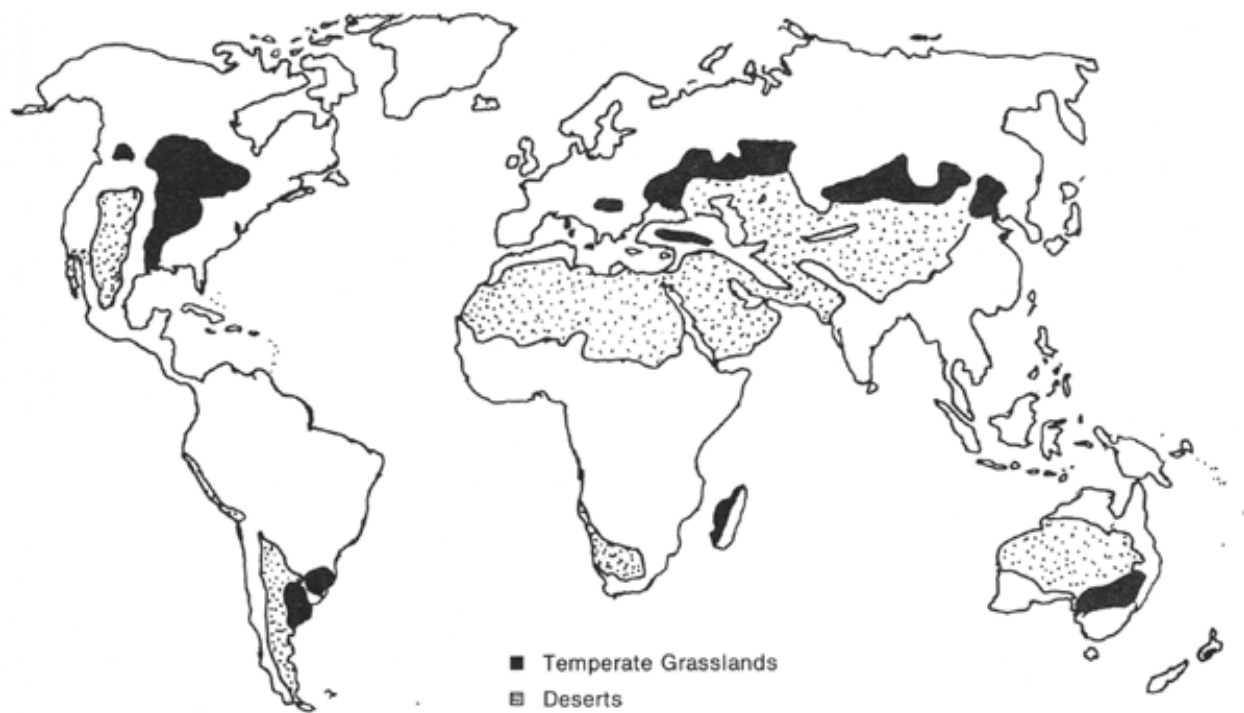


**Fig. R 3-2.** Centers and noncenters of agricultural origins: (A1), Near East center, (A2), African noncenter, (B1), North Chinese center, (B2), Southeast Asian and South Pacific noncenter, (C1), Mesoamerican center, and (C2), South American noncenter (from Harlan, 1971; copyright © 1971 by the American Association for the Advancement of Science).

The steppes tend to be marginal, and they are an unlikely place to begin. The few domestic plants that might be of steppic origin are *Panicum miliaceum*, *Setaria italica*, and *Cannabis sativa*. One invaluable contribution, however, came from *Aegilops squarrosa*, a plant of the central Asian steppes that provided the D genome of hexaploid wheat. This may be why wheat can be grown on such a scale on the temperate steppes of the world.

The tropical rain forests, Fig. 4, provide a very difficult environment. We do not know of a single hunting-gathering society of rain forests that does not require some supplementation from cultivated plants (Bailey et al., 1989). We have no evidence of early occupation of either the Amazonian or African rain forest. Certainly, the present rain forest of Amazonia has been strongly modified by activities of farming people and does not represent the original conditions faced by the first colonizers. It is probable that agriculture must first be developed and adapted to this difficult environment before people could live in it yearlong. Of the major crops listed in Table 1, those that might have come from a rain forest environment are: sugarcane, bananas and plantains, orange and mango, but these are not plants of the closed canopy. They are adapted to the forest margins, stream banks and modified forests where they can receive more sunlight than in a high closed canopy forest. This tends to be true of other products of tropical forest. The formation as a whole has yielded a large number of useful plants, mostly fruits and nuts and some of these will be mentioned in later chapters. While the forest-savanna ecotone is rich in potential, the forest itself is an inhospitable place to begin agriculture.

Deserts, Fig. 3, have some possibilities, if there is water available. The Sonoran complex evolved with local domestication of the tepary bean, devil's claw, and *Panicum sonorum*. Other parts of the complex, maize, beans, and cotton were presumably obtained from farther south in Mexico. The squash awaits further clarification since there appears to be multiple domestication's. In Africa and the Near East, the date was a major contribution from the desert environment and pearl millet was probably domesticated in the Sahara. *Prosopis*, *Acacia*, *Zizyphus*, *Borassus*, and other trees have been heavily exploited if not domesticated. No desert crop has made the select list and the environment is generally a very unlikely one for the beginnings of agriculture.



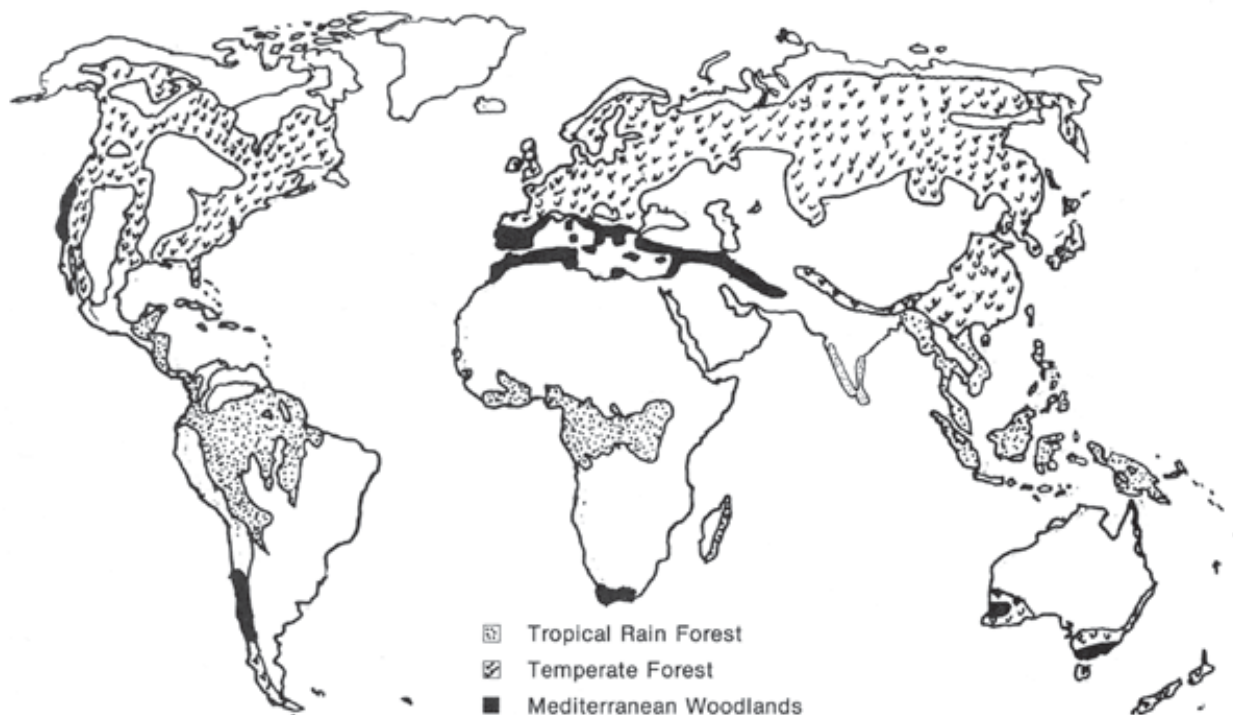
**Fig. R 3-3.** Well-developed temperate prairies and deserts.



Temperate forests, Fig. 4, have somewhat better possibilities. Clearings can be made by deadening trees. The soils of loess terraces, at least, are friable and easily worked with primitive tools, and leaf mould and litter can be helpful in soil conditioning. The contributions, as one would expect, have been primarily in fruits and nuts, e.g., apple, pear, peach, cherry, quince, plum, grape, walnut, hickory, pecan, hazelnut, chestnut, buckeye, oak, etc., the last two usually requiring detoxification. A small complex developed in eastern North America where *Iva*, *Chenopodium*, *Phalaris*, *Polygonum*, *Ambrosia*, *Hordeum pusillum*, possibly a *Cucurbita* and sunflower were domesticated (Watson, 1989). Still, cultivation of such plants seems to be late and they were gathered from the wild long after other crops had been domesticated. On the whole, temperate forests are benign environments and agriculture was unnecessary until rather late in prehistory; see comments on Jomon of Japan, Chapter 10.

It is when we come to the Mediterranean woodlands, Fig. 4, and tropical savannas, Fig. 5, that we hit the jackpot. These two formations have provided most of the plants on the elite list and a large number of others that produce less but are important. The two formations have one feature in common—long dry seasons. The Mediterranean climate has a summer dry season, the savanna a winter dry season, and the duration of a water-deficit period is critical. Long dry seasons generate annuals and plants that behave as annuals. Today, the human race is nourished by such plants, Table 1.

A look at Fig. 4 suggests why the Near East appears to have a center of origin. The region of winter rainfall and summer drought is relatively small to begin with, and the area where distributions of wild wheat, barley, sheep, and goats overlap is even smaller. This climatic regime and vegetative formation occurs on the western side of land masses between 30° and 40° north and south. South Africa and southern Australia just reach the zone, while California and Chile intercept the full width. These last zones are restricted to the east by high mountains. The largest area of this climatic regime and associated vegetation is, therefore, around the Mediterranean and fanning eastward into the deserts of Iran and Afghanistan. The portion of the area with adequate rainfall for good development of wild cereals and consequently of dryland farming is restricted to an arc along the Zagros and Tauros mountains at mid-elevations and down the Levant to a little south of Jerusalem. We probably have a “center” because it could not have happened any other way. This did not exclude the possibilities of independent developments elsewhere.



**Fig. R 3-4.** Tropical rainforests, temperate forests, and Mediterranean woodlands.



On the list of 30 major food crops, the Mediterranean region contributed: wheat, barley, pea, rapeseed, and the wild races of oats and rye. The annual production is on the order of 730 million metric tons.

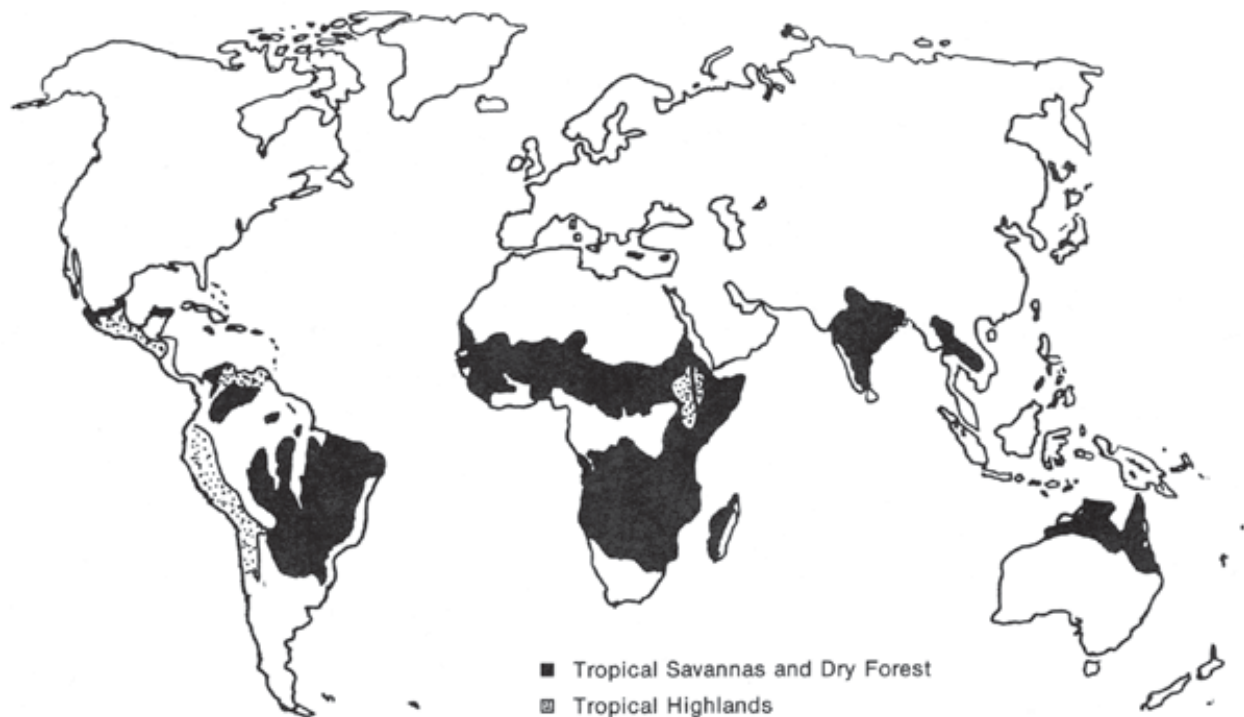
The savanna formation includes both open grasslands with widely scattered trees and dry forest where the dry season lasts some 5-8 mo each year. The regime favors both seedy annuals and plants with tubers that behave like annuals. Tuber formation is an adaptation to long dry seasons. At the onset of the rains, the tubers of yams, for example, sprout and the vines grow with remarkable vigor; virtually the entire contents of the tuber are mobilized and trans-located upward. At the end of the rains, the process is reversed and nearly all of the food stored in the vine is trans-located downward and the tuber grows very rapidly. The vine dies and the tuber remains dormant through the dry season and safe from fires that often burn the vegetation at that time.

The annual habit is also suited to long dry seasons. Seeds can survive the drought and sprout at the onset of the rains. The annual races of wild rice grow in waterholes that stand in water during the rains and dry up in the dry season. Wild maize (teosinte) is adapted to open dry forest at mid-elevation in Mesoamerica. On our select list of food crops, the savanna and dry forests can claim: maize, rice, sorghum, cassava, sweet potato, bean, peanut, yams, cotton (seed oil) with an annual production of some 960 million metric tons.

Tropical highlands, Fig. 5, have yielded some major crops and many minor ones. An important suite of crops evolved in the Andes. On the world scene, the important one is potato, but others are very important locally. Some are listed in Table 3-1 (Chapter 3), and mentioned in Chapter 11. Economically, the most important contribution of the East African highlands is arabica coffee. This is not a food crop, but generates a lot of money and money can buy food, so it is important on the world scene. Other crops of the region are treated in Chapter 9.

The sea coasts of the world have provided some important crops. On the select list, these include coconut, cabbage, and beet. Radish and a few others can be added. The coconut may have some considerable antiquity as a cultivated plant, but the others appear to be rather late.

Seen from an ecological perspective, early agriculture could have evolved in a variety of settings, but the greatest opportunities would be in regions with long dry seasons where a wide selection of annual seed crop progenitors and seasonal tuber crop progenitors was available.



**Fig. R 3-5.** Tropical savannas and dry forests, and tropical highlands.

**Conclusions**

I still think it unlikely that one model would explain all situations. There are too many independent beginnings for that. One scenario that is likely is one in which people of a well-developed delayed return hunter-gathering society began to grow one or a few special species in gardens, perhaps for fun, perhaps for convenience, perhaps to bridge a lean time in the gathering schedule, but more likely, to my mind, to raise a chosen plant in a spiritually safe space free of malevolent forces.

Such a scenario would be as much a nonevent as the Kuruk growing tobacco. The change would be completely trivial until and unless the early initiative of small scale gardening evolved into true food production, and this might take millennia. It may be that agriculture slipped through the back door without anyone noticing. This scenario seems to fit the evidence from Oaxaca, and the Andes and the mid-western USA. Probably other scenarios were played out in the Old World.

If this view of American “neolithization” is more or less correct, then the major changes and adjustments of human adaptation came *before plant cultivation and we should be looking at what motivated changes in the epipai-palaeolithic or Mesolithic. What prompted people all over the world to make smaller, more elegant and more efficient tools and weapons? What prompted them to take to the water in rafts, canoes, boats, make harpoons, fish hooks, nets, traps, weirs, etc.? What motivated a broader spectrum of hunting and gathering? Here, we do not have to look far for incentives. With all that ice melting and sea levels rising, it was a watery world, and with mass faunal extinction, other resources had to be exploited. After the adjustments were made, the best opportunities for initiation of plant cultivation would be in areas with long dry seasons, whether temperate or tropical.*

**Table 1. The world's 30 leading food crops in terms of estimated edible dry matter.**

Crop	Million Tonnes <sup>2</sup>		Ecological Origins	Pollination	Ploidy level (× no.)
Wheat	468	Annual	Mediterranean	Self	2,4,6
Maize	429	Annual	Savanna	Cross	2
Rice	330	Annual	Savanna	Self	2
Barley	160	Annual	Mediterranean	Self	2
Soybean	88	Annual	Woodlands	Self	4
Cane Sugar	67	Perennial	Tropical forest	C (veg. prop)	many
Sorghum	60	Annual	Savanna	Self	2
Potato	54	Annual	Highlands	C (veg. prop)	2,4,6
Oats	43	Annual	Mediterranean	Self	2,4,6
Cassava	41	Perennial	Savanna	—	4
Sweet Potato	35	Annual	Savanna	C (veg. prop)	6
Beet Sugar	34	Annual	Coastal	Cross	2,a,4
Rye	29	Annual	Mediterranean	Cross	2
Millets	26	Annual	Savanna	S/C	2,4
Rapeseed	19	Annual	Mediterranean	Cross	4,6
Bean	14	Annual	Savanna	Self	2
Peanut	13	Annual	Savanna	Self	4
Pea	12	Annual	Mediterranean	Self	2
Musa	11	Perennial	Tropical forest	—	3
Grape	11	Perennial	Woodlands	—	2
Sunflower	9.7	Annual	Prairie	Cross	2
Yams	6.3	Annual	Savanna	—	many
Apple	5.5	Perennial	Woodlands	C (veg. prop)	2
Coconut	5.3	Perennial	Coastal	Cross	2
Cottonseed (oil)	4.8	Annual	Savanna	Cross	4
Orange	4.4	Perennial	Tropical forest	C (veg. prop)	2,3
Tomato	3.3	Annual	Coastal	Self	2
Cabbage	3.0	Annual	Coastal	Cross	2
Onion	2.6	Annual	?	Cross	2
Mango	1.8	Perennial	Tropical forest	C (veg. prop)	2

**Food Crop Group Totals (millions of tonnes)**

Cereals	1545	Tubers	136.3
Pulses	127	Fruits	33.7
Sugar	101		
Annuals	2047	Perennials	147
Mediterranean and Savanna (long dry seasons)			1990
Edible dry matter of all meats, milk, and eggs			119

<sup>2</sup> less wastage; e.g., rice hulls, peels, shells, seeds, non-edible parts, etc., less moisture content from tables in Morrison (1956); Ensminger, et al. (1983); or Adams (1988). Source: FAO yearbook 1985-1987.