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EARLY AGRICULTURAL SOCIETIES

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TRANSITIONS TO AGRICULTURE

The successful shift from a subsistence economy based wholly on foraging to one based primarily on food production was one of the most significant developments in the existence of the genus *Homo*. For several million years, human beings had obtained their diet first from scavenging, then from hunting, fishing, and collecting. Within approximately the last 10,000 years, markedly different subsistence economies based on cultivated plants and, in many areas, domesticated animals, have replaced hunting and gathering around the world. When viewed from this perspective, the origin and dispersal of food production took place very rapidly. Within these last ten millennia, however, the process of domestication or adoption of domesticates occurred at varying time-scales based on local environmental, economic, and social conditions.

The origins and dispersal of food production have attracted the attention of researchers for several decades and have come to be a major focus of archaeological research. Much of this research has been concentrated on the areas and periods in which plants and animals were first domesticated from indigenous wild species. Some (for example, Minnis 1985) have used the term 'pristine domestication' to refer to such situations in which the human control and manipulation of a species are sufficient to cause phenotypic changes for the first time. A considerably less-developed research orientation is the study of the adoption of domesticated plants and animals and the techniques of agriculture and animal husbandry by populations who did not domesticate the species themselves, as well as the spread of populations practising agriculture into areas where it had been hitherto unknown. As Minnis (1985:309) points out, such cases have been more frequent and more widespread than the instances of pristine domestication, and he uses the term 'primary crop acquisition' to describe them.

Early views of the transition held that it was an inevitable development on the road to civilization. Yet more thoughtful analyses of this shift in the last three decades have shown that it was not that simple. Much of our understanding of the ramifications of the change from foraging to farming comes from comparative ethnological studies of the remaining hunter-gatherer and incipient agricultural populations on the face of the earth. These studies have shown that foragers have some economic and social options that are not open to farmers and that farmers have other options not open to foragers. For instance, foragers have the option of mobility to respond to local environmental variation, while farmers are tethered to their fields. Foragers often have access to a range of food resources, while agriculture and grazing may reduce the variability in an ecosystem and reduce the number of dietary options. On the other hand, the concentration of food resources made possible by agriculture and animal husbandry can open up social options for exchange and alliances that may be limited for hunter-gatherers. The study of the transition to agriculture, then, attempts to identify the reasons why hunter-gatherers, either by choice or by necessity, found that the advantages of an economic system involving food production outweighed the options available to them as foragers.

THE ORIGINS OF AGRICULTURE

Approaches to the origins of food production in archaeology can be divided into two research orientations, each of which relies upon the other. The first includes both the methodological focus on the recovery of data relating to the phenotypic characteristics of seeds and bones that reflect the changes associated with human control and manipulation and the modelling of the sequence of these changes. In the last thirty years, the development of recovery techniques for small-scale remains, particularly seeds, has exponentially enlarged the corpus of data on early agriculture. Specialists in botanical and faunal analysis are now readily incorporated into archaeological research projects specifically to ask questions about the types of plants and animals used by inhabitants of archaeological sites, rather than to provide a species list appended to a report. New techniques, often involving microscopy and other technical methods of analysis, have been introduced. For instance, in the late 1970s the study of phytoliths, accelerator mass spectrometer (AMS) radio-carbon dating, and the analysis of bone for trace elements and stable isotopes were virtually unknown, while today they are frequently used to ask questions about the origins of food production in various parts of the world. As a result, archaeologists, archaeobotanists, and archaeozoologists have been able to trace the sequence of changes in relations between humans and plant and animal communities with progressively finer resolution.

The other aspect of the study of the transition to agriculture is the modelling of the process by which foraging populations first began to control and manipulate plants and animals. The goal of such studies is to identify the causal links in the sequence of agricultural origins that had the effect of transforming human societies by leading humans to turn from foraging to farming. Clearly this undertaking involves the generation and testing of hypotheses and the reconciliation of often-contradictory evidence. Although it has proved impossible to isolate an unequivocal cause for the transition from foraging to farming, archaeologists have no shortage of theories which provide a variety of reasons for this change.

Seeds of domestication

In 1971, Harlan identified three main centres of pristine domestication within which the major complexes of domesticated plants and animals which transformed prehistoric society were first established (Fig. 21.1). These are the Near East (emmer and einkorn wheat, barley, peas, lentils, sheep, and goats), northern China (millet and rice), and Mesoamerica (beans, chillies, maize, and gourds). To Harlan's three localized centres of domestication can be added one more which has come to light in the last fifteen years. In eastern North America, Smith (1989) has argued for the presence of an independently developed complex of domesticates that includes squash, sump-weed or marsh-elder, sunflower, and chenopod. In addition to these focal points in which pristine domestication was part of a complex transformation of society, Harlan also identified three larger, non-localized, regions in which domestication of a number of species of plants and animals also occurred. In South America, the potato and several camelid species became critical resources for highland populations, while in the lowlands manioc became a staple food. In the northern half of Africa, sorghum and possibly millet and cattle were early domesticates. Finally, there is the broad region of south-east Asia and the Pacific islands in which a complex of tree and root crops was managed, cultivated, and domesticated.

Within most of these localized centres and diffuse regions, an extraordinary amount of research has occurred in the last thirty years to document the initial appearance of domesticated species. The techniques for the recovery, identification, analysis and interpretation of botanical and faunal remains have been improved markedly. Whereas in the late 1960s there had been only a handful of individuals around the world with expertise in these materials, now there is an expanded cohort of researchers who have developed the necessary skills in identification and analysis for many additional species. To this broadened research base, the technique of radio-carbon dating using an accelerator mass spectrometer was added during the

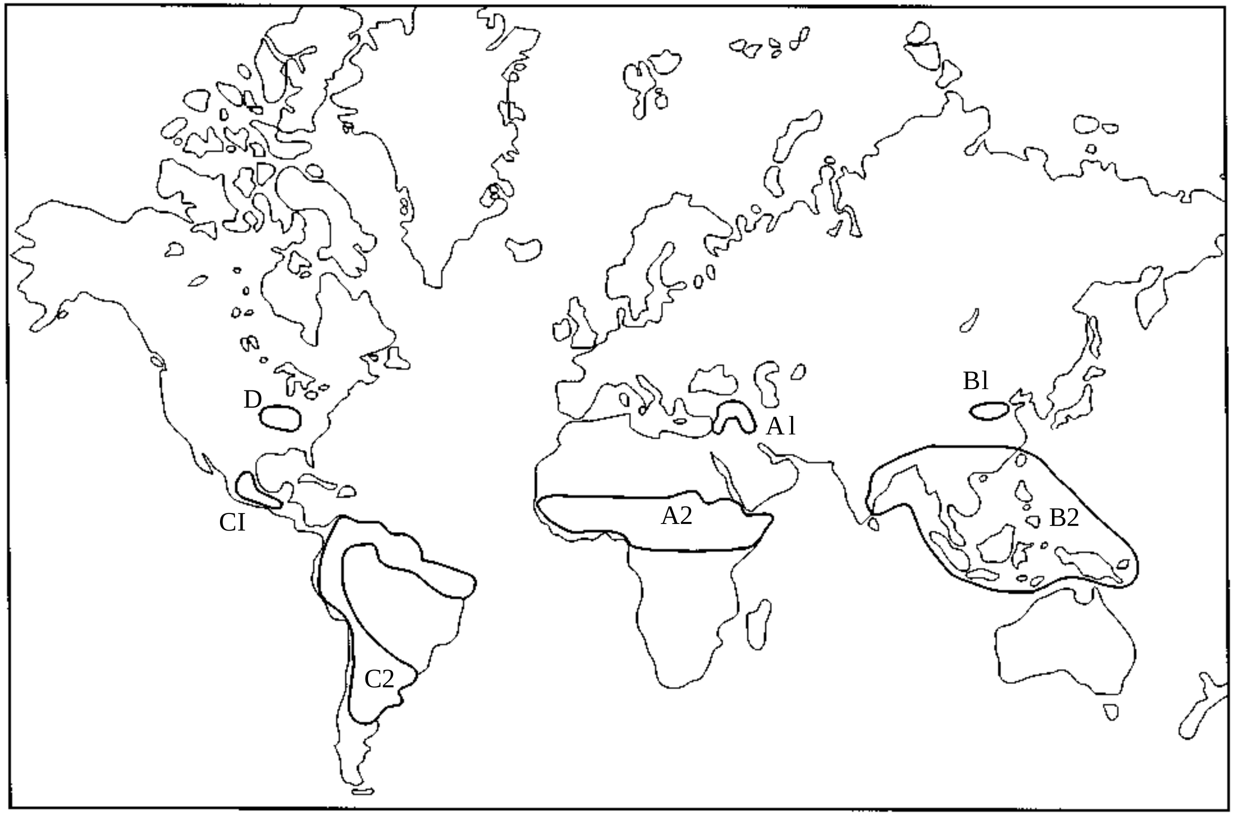

Figure 21.1 Centres and regions of pristine domestication. A1–C2: Source: Harlan, 1995, with permission of Cambridge University Press; D: Source: Smith, 'Rivers of change: essays in early agriculture in eastern North America', Science, 246: 1566–71, 1992. Adapted by D.Miles-Williams.

1980s. While this method is still expensive and not universally applied, it has enabled the dating of very small (under 5 mg) samples such as individual seeds or small fragments of animal bones. Much of the evidence for early plant domestication in eastern North America, for instance, rests on AMS dating.

Figure 21.2 offers a simplified chronology of early plant and animal domestication in the above centres and broader regions, though it must be stressed that it is impossible to summarize the current state of knowledge of the complexity of the process, particularly in terms of phylogenetics. The reader is best referred to several recent summaries which should form the baseline for knowledge for some time (for example: Clutton-Brock 1989; Crabtree 1993; Gebauer and Price 1992; Harlan 1995; Harris and Hillman 1989; Price and Gebauer 1995; Smith 1995; Watson and Cowan 1992; Zohary and Hopf 1993). Groups of archaeobotanists and archaeozoologists meet with regularity, and there is normally a major revelation at each of these gatherings.

Taking one step back from the seeds and bones themselves, it is important to consider the process of domestication, first by describing it and then by looking for factors that caused it. Rindos (1984) has proposed a typology of three different sorts of domestication, which he terms 'incidental', 'specialized', and 'agricultural'. Incidental domestication occurs when humans become the agents by which a species is removed from its native habitat and, in some sense, protected and exploited in its new setting. Specialized domestication is an outgrowth of incidental domestication in which humans begin to exhibit conscious and directed behaviour to propagate wild species and to begin to depend on them. Agricultural domestication involves the appearance of behaviour which completely transforms and alters the relationship between hitherto-wild species and humans by controlling the ecology and evolution of the domesticated taxa. Harvesting, seed selection and storage, weeding and removal of competitors, and tillage are all characteristic of agricultural domestication. In Rindos's view, while the origin of domesticated species is important, the more important transformation that occurs in the origins of agriculture is the change that is wrought in the ecosystem, specifically the relationships and interdependencies between plants, animals, and humans.

Ford (1985), writing from the perspective of the prehistory of the south-western United States, takes a somewhat different approach to the sequence of domestication. He distinguishes somewhat sharply between 'foraging' and 'food production' as the poles of the domestication continuum, while dividing the latter into stages of 'cultivation' and 'domestication'. Cutting across these stages of food production are a succession of methods, which Ford characterizes as 'incipient agriculture', 'gardening', and 'field agriculture', within which is a progressively more elaborate set of human activities, ranging from tending through tilling, transplanting, and sowing, to plant breeding.

An elaboration of the above sequences has been presented by Harris (1989), with

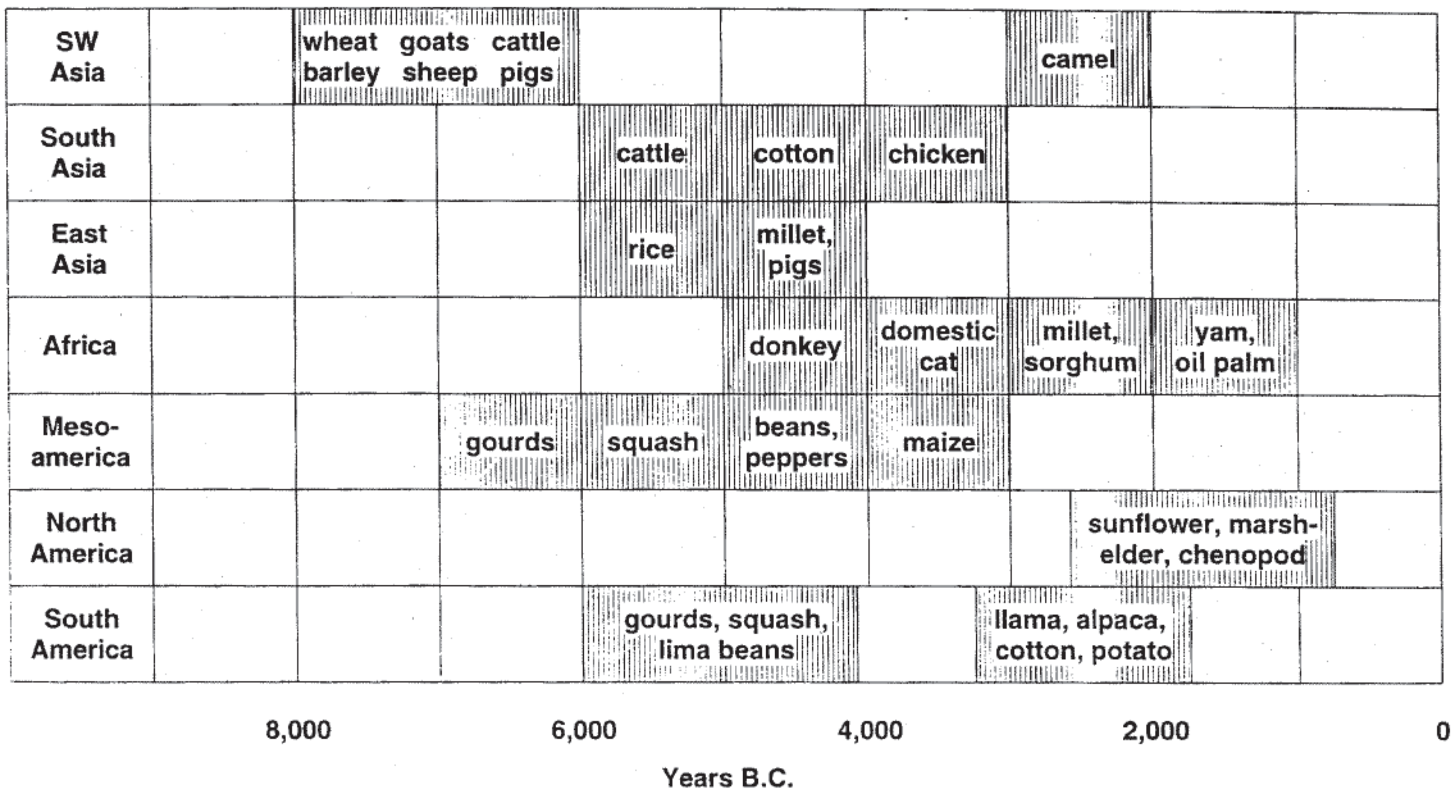

Figure 21.2 A simplified chronology of plant and animal domestication. After Price and Feinman 1993:127, with changes to reflect recent advances in dating after B.Smith 1995 and Harlan 1995.

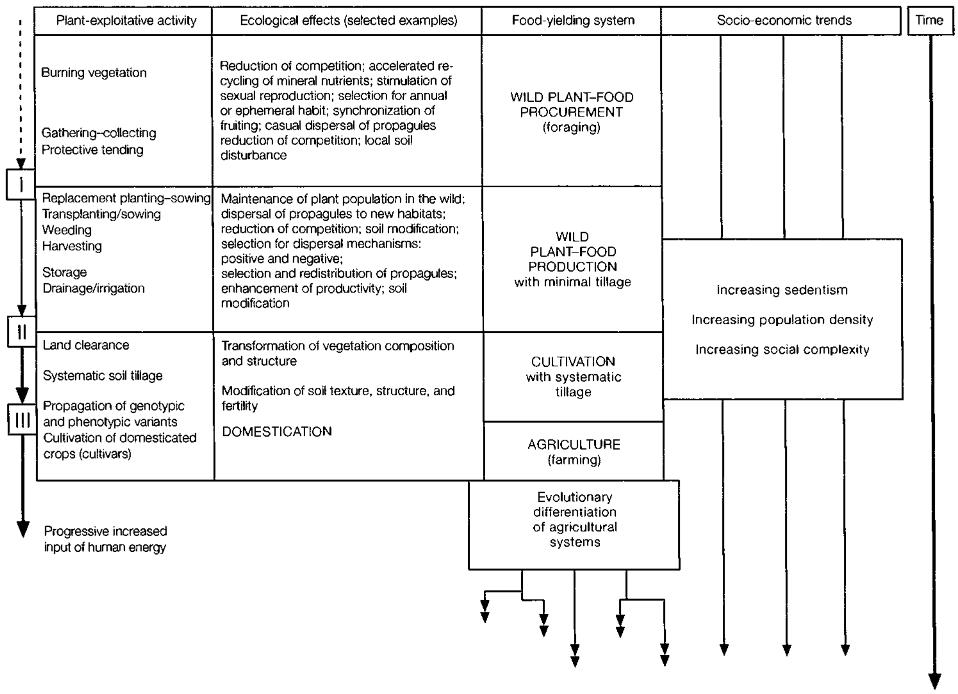

Figure 21.3 Evolutionary sequence describing the origins of cultivation; the Roman numerals at the left indicate thresholds at which a significant increase in energy investment is hypothesized to have occurred. Source: after D.R.Harris 1989, Fig. 1.1.

the addition of several thresholds in which the input of energy into food procurement and production was stepped up (Fig. 21.3). Harris begins with foraging, to include such activities as controlled burning of vegetation, gathering, and protective tending. Food production, in Harris's view, begins with the first leap in energy input, involving sowing, weeding, harvesting, storage, and drainage/irrigation (yet with minimum of tillage). At this point, the plants being used are still phyto-genetically wild. The second step up in energy input comes with the transformation of the environment through land clearance and systematic tillage. Finally, the third step, marked with another jump in energy investment, is the propagation of specific variants of the plants being used; namely, the actual domestication of the cultigens. It is at this point, in Harris's model, that agriculture truly begins, with the establishment of true agro-ecosystems.

The schema of Rindos, Ford, and Harris refer largely to plant domestication. With the study of animal domestication, more emphasis has been placed on the characteristics that mark the appearance of domestic forms rather than the shifts in human cultural activities that led up to domestication. An important universal characteristic of the development of animal domestication, which differentiates it clearly from plant domestication, is the shift from the importance of the *dead* animal for its meat alone to the selective propagation of the *living* animal (Meadow 1984, 1989) as a part of a breeding population. Another key difference between animal and plant domestication is that animal populations exhibit social behaviour which conditions their interaction with humans. The behavioural characteristics of the animals that were domesticated in prehistory vary widely, and as a result the sequence of domestication is also variable. The result is that there is greater consideration given to local patterns rather than to models that have global applicability, as well as to models that emphasize the interplay with the local progression of plant domestication (for example, Hole 1984). In general, there is a clear sense that the process of animal domestication was relatively quicker than with plants, with the more important aspect being its subsequent differentiation of emphases in animal husbandry and the products it yielded.

Evolutionary sequences such as those presented above *describe* rather than *explain* the progression of human cultural activities that culminate in domestication and agriculture: they do not provide the causal factors that move the process from one stage to the next. In other words, why did humans add weeding, harvesting, and storage to their earlier foraging activities and then proceed to clear land, till the soil, and propagate specific variants of edible plants? Why did they begin to control and breed herd animals like sheep and goats? Archaeologists have proposed a number of different models for the reliance of human populations on domesticated plants and animals, which are discussed in the following section.

Causes of food production

Once the question shifted from 'how' did food production develop to 'why', anthropological archaeologists began to try to identify causal factors which resulted in a shift from economies based on foraging to ones based on cultivation and livestock. In doing so, they develop models which seek to explain, not simply describe, this process. 'Explanation' implies a search for causation, and the models that archaeologists develop to explain the transition to food production involve an attempt to identify factors which caused societies to make this change. Some models try to isolate single factors, while others propose an interplay of several. It would be impossible to do justice here to all of the models that have been proposed, especially in the last twenty-five years, and this section will attempt simply to illustrate the variation in explanations that have been put forward.

In the first decades of this century there was relatively little attempt made to explain the origins of agriculture. As was often the case, the first real attempt to seek causality in the transition to food production was advanced by V.Gordon

Childe, who proposed his 'desiccation' or 'oasis' theory in 1928. Childe suggested that global warming and desiccation at the end of the last ice age led to the concentration of humans, plants, and animals in circumscribed locations, such as oases, and the sheer 'propinquity' or proximity of these species led to the establishment of human control over the eventual domesticates. The difficulty was that available evidence indicated a stable climate, without widespread desiccation, during the period in question between 15,000 and 10,000 years ago. Childe's theory was later overtaken by the view of Braidwood (for example, Braidwood 1960), who suggested that food production in the Old World emerged in certain 'nuclear zones' in the arc of the Taurus and Zagros mountains of the Near East known as the Fertile Crescent. Again, the mere proximity and familiarity of humans with the suite of emmer, einkorn, barley, sheep and goat would have led to the establishment of relations of control and manipulation which resulted in domestication. The advantages of domesticated plants and animals would have been so obvious that this would have become the dominant subsistence strategy in short order.

In the late 1960s there was a shift in anthropological thinking away from a belief in the inherent superiority or attractiveness of agriculture as an economic strategy. Instead, there emerged a prevalent belief that foraging was a successful and stable way of life and that humans would not have taken on the drudgery and risks of agriculture unless they were under duress. None the less, it was clear that in the last 10,000 years virtually all the world's population had made this transition, and the search for the factors which would have compelled humans to make it was intensified. Since 1968, there have been many different theories of the origins of food production that have been proposed, but they can be grouped under several convenient rubrics. Barbara Stark, in a review of the origins of food production in the New World, has identified three main types of models used by archaeologists to trace the transition to food production (Stark 1986), which she terms 'push' models, 'pull' models, and 'social' models (Fig. 21.4). This typology of models is also germane to the study of the origins of food production in the Old World.

'Push' models are by far the most commonly encountered in the archaeological literature. They tend to highlight the presumed duress which would have driven humans to adopt the time-consuming and risky business of food production. Such models, including those proposed by Binford (1968), Flannery (1969), and Cohen (1977) among others, are based on imbalances between population and resources and human populations acting under conditions of stress. Population growth, in an elaboration of the position taken by Boserup (1965), is often regarded as the main 'motor' which propels the sequence of causal relationships, with climatic change often introduced as the trigger which causes a sudden imbalance in the system. Other elements in such models are the emergence of sedentism and the diversification of resource use among terminal hunter-gatherers. As Henry (1989) points out, the main source of variation among the 'push' models is the sequence in which

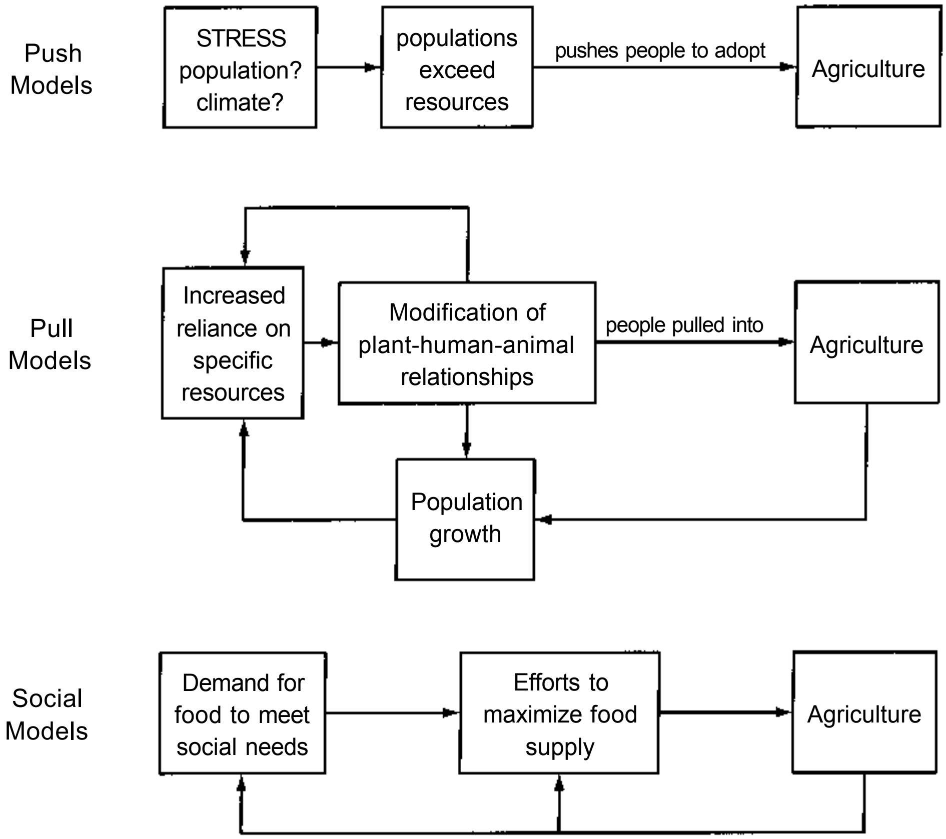

Figure 21.4 Schematic representation of the general arguments underlying 'push', 'pull' and 'social' models of the transition to agriculture. Source: P.Bogucki.

these three key elements are ordered. They are attractive in that the characteristics of sedentism, diversification of resources, and population growth can often be plausibly, if not necessarily conclusively, inferred from archaeological data.

An early example of a 'push' model was that of Binford (1968), who proposed that in certain coastal regions of the world, such as the Levant, populations that relied on rich marine resources grew in size. These populations increased to the point at which they were forced to spill over into adjacent inland zones which were not so richly endowed, also perhaps pushed by a hypothesized rise in sea levels at the close of the Pleistocene. In these marginal zones, these spillover populations needed to increase the resource base artificially, and they did so by sowing wild seeds of grasses like wheat and barley taken from the optimal zones. There is, however, no evidence of large late Pleistocene populations supported by aquatic resources in these regions, so Binford's model has remained unsupported, yet it is important in that it introduced demographic pressure as a causal factor in the discussion of agricultural origins.

Flannery (1969) proposed a model of agricultural origins in the Near East which incorporated many of the elements of Binford's scheme. He argued that, beginning about 20,000 BC, populations in the Near East began to broaden their subsistence base to include all sorts of previously underused plant and animal species—what he termed a 'broad spectrum' pattern. Human populations in certain optimal zones of the Fertile Crescent, where there were large natural populations of wild wheat, barley, sheep and goat, grew to the point where they exceeded the capacity of these regions to support them. At this point, about 8000 BC, they spilled over into adjacent marginal zones, whereupon cultivation began as an attempt to produce artificial stands of cereals 'as dense as those in the *heart* of the "optimum" zone' (Flannery 1969:81). At this point, phytogenetic changes in the cereals, such as the toughening of the rachis, set in to reinforce the human efforts. Still, harvests were uneven, and the domestication of sheep and goat was an effort to 'bank' food in an attempt to buffer the lean years. Flannery's model was seen as very compelling, and although some have made amendments to it (for example: Hassan 1977; Smith and Young 1972), it remained the basis for the genre of 'push' models of agricultural origins in south-western Asia throughout the 1970s. Attempts have been made to extend the population pressure hypothesis of agricultural origins world-wide (Cohen 1977), but the absence of compelling evidence from many regions has led many archaeologists to be sceptical of it as a universal explanation.

More recently, a certain dissatisfaction with single-factor 'push' models has set in, particularly due to the fact that demonstrating stress or inferring it from population growth is elusive. Moreover, it began to seem clear that the earliest sites with documented plant cultivation and animal husbandry were not in 'marginal zones' but rather in the most productive parts of the Levant. Recent models (McCorriston and Hole 1991; Moore 1982, 1989) have tended to emphasize the interplay of a variety of factors, including changing environments, demography, the foraging economy, settlement patterns, and social organization. The differences among them tend to be the factor which receives the heaviest weight. Moore (1982, 1989), for instance, emphasizes the change to a more sedentary form of settlement which increased pressure on local plant and animal resources. McCorriston and Hole (1991), on the other hand, stress the role of environmental change, as manifested in increased seasonal variation and the drying of lake basins. The increased prominence given to climatic change in many recent models indicates that Childe's speculations of the early twentieth century were not entirely wide of the mark.

Some archaeologists are not comfortable with isolating a source of 'stress' which compelled populations to shift from foraging to farming and have developed so-called 'pull' models, although these are somewhat rarer in the archaeological literature. In such models, the precursors of domesticated plants and animals are inferred to have had certain characteristics which drew human groups to rely more heavily on them than on alternative resources. The increased use of such resources then led to dependence on them to the point that it was impossible to return to the previous patterns of plant and animal exploitation. In such models, population growth continues to play a role, but it functions more as the force that prevents a group from reverting to an earlier pattern of resource use that maintained population at a lower level.

In highland Mesoamerica, Kent Flannery proposed one of the earliest 'pull' models in 1968. He argued that the foraging bands of upland Mesoamerica practised a tightly scheduled seasonal pattern of plant and animal exploitation. Subtle genetic changes in particular plants, especially beans and eventually maize, made them more attractive to foragers, who spent more time collecting them. This upset the tight schedule, leaving the foragers no option but to cultivate the plants on which they had focused in order to maintain their yields. Although it has been refined somewhat over the last two decades (for example, Flannery 1986), this model presents an attractive explanation of the beginnings of cultivation in Mesoamerica, although recent research results may revise our understanding of early agriculture in this region in the near future. For example, the transition from foraging to farming societies was long believed to be very gradual, based on radiocarbon dates of *c.* 5000 BC for maize cobs in the Tehuacan Valley and the eventual appearance of maize-based agricultural villages *c.* 2000 BC. Recent AMS dates, however, indicate that maize domestication may have occurred later, *c.* 3500–3000 BC (Fritz 1994).

Henry (1989) has developed a 'pull' model for agricultural origins in the Near East. He proposed that there were two key points in the process of agricultural origins in the Levant. The first occurred around 12,500 years ago, in which a world-wide increase in temperature promoted long-term settlement and necessitated a shift from what Henry calls 'simple' foraging to 'complex' foraging in the Levant, in which a variety of high-yield resources were exploited, including wild cereals. Restraints on population growth were relaxed. About 2,000 years later, this complex foraging system collapsed, possibly as the result of a second climatic change. The foragers had two options. In the highly productive areas of the Levant, where the highest populations were, they began to cultivate cereals (which, Henry believes, they had known how to do for some time, but had not needed to), while in the marginal areas they reverted to a simpler foraging system.

In 'social' models, factors beyond population growth generate demand for resources, leading to the intensification of subsistence pursuits and ultimately to food production. Among some human groups, it is hypothesized, there existed a need to increase the amount of food available to meet social demands for exchange, bridewealth, distribution for status, and alliance formation. The high productivity of certain potential domesticates led to a concentration on them for this purpose and ultimately to their domestication. The evidence to support 'social' models is quite elusive and requires crossing a wider inferential gap than for 'push' and 'pull' models. None the less, they should not be discounted simply because it is difficult to find direct support for them.

A recent 'social' model for the origins of food production is that of Hayden (1992), which he terms the 'competitive feasting' model. Hayden points out that most hunter-gatherers occupying fluctuating environments share food, and hence there is no incentive to invest time and effort in producing extra, since only others will benefit. In resource-rich areas, however, in which there was adequate food to relax such collective sharing, conditions may have arisen for competition as ambitious individuals staged competitive feasts to gain control over labour and loyalty. The need to generate large amounts of desirable foods in order to stage such competitive feasts stimulated cultivation, which represented no great discovery for foragers who were well aware of seeds and their propagation. Hayden proposes his model without strict geographical reference, suggesting that it may be applicable to both the New World and Old World alike. Similarly, Runnels and van Andel (1988) have argued that in the eastern Mediterranean agriculture may have arisen as a result of a need to produce surplus commodities for trade or to support craftsmen who made goods for trade.

THE DISPERSAL OF FOOD PRODUCTION

The question of the spread of agriculture and animal husbandry beyond the zones of initial domestication is just as important as the process of domestication itself. In addressing this issue, a variety of factors must be studied. It is necessary to differentiate between the expansion of agricultural communities into zones where they previously had not been found and the adoption of the techniques of agriculture and animal husbandry by communities that had previously practised only foraging. Both types of agricultural dispersals took place at various times around the world.

A number of different factors need to be taken into account in studying agricultural dispersals. One is the organization of early farming communities and why they might be expected to expand into new ecological zones. Another factor is the environmental conditions that prevailed at the moment when domestic plants and animals became available to local foraging populations and whether these encouraged or retarded the adoption of food production. Finally, it is necessary to understand the nature of the foraging populations that inhabited the area prior to the appearance of cultivation and animal husbandry.

Agricultural dispersal by colonization of wide areas was apparently rare in prehistory, but it can be documented for certain regions with some level of confidence. For instance, on the loess soils of central Europe, an area hitherto sparsely settled by foraging peoples, communities of the Linear Pottery culture settled

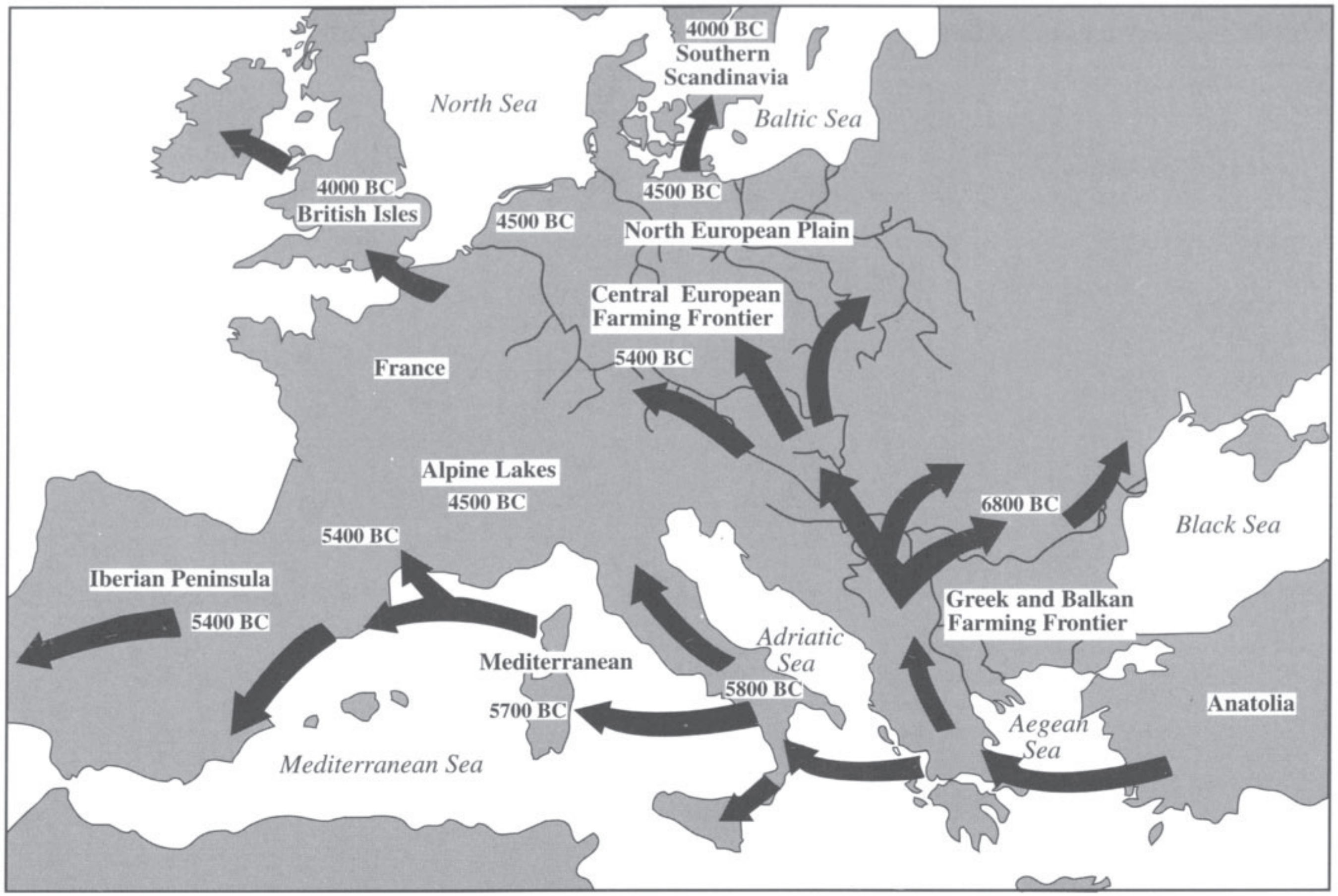

Figure 21.5 Agricultural dispersals in Europe, *c*. 6000-3000 BC. Note that the dispersal is not constant but rather that in the Balkans and in central Europe there were periods during which the frontier did not advance steadily. Reproduced with permission of *American Scientist*.

between 6000 and 5000 BC (Barker 1985; Bogucki 1988, 1996; Bogucki and Grygiel 1993; Hodder 1992; Price *et al.* 1995). Sharp contrasts in house form, chipped-stone tool types, and settlement location between earlier foragers and the Linear Pottery culture, and its fully developed pottery technology, suggest that this does indeed represent the spread of agriculture through the dispersal of people (Fig. 21.5). Similarly, the Austronesian-speaking colonization of Polynesia between *c.* 1600 and 500 BC brought with it a dispersal of cultigens and domestic animals (pig, dog and fowl), along with a variety of 'stowaways', including lizards, rodents, molluscs and weeds (Kirch 1983).

A more frequent occurrence in prehistory was the adoption of agriculture and animal husbandry by peoples who had previously engaged in foraging—what Minnis (1985) calls 'primary crop acquisition'. Indeed, outside of the rare instances of colonization, the adoption of agriculture by foragers has been the dominant mode of agricultural dispersals over the last ten millennia. As Minnis (1985:337) points out, however, the adoption of cultigens by foragers has received comparatively little attention alongside cases of pristine domestication. Yet 'primary crop acquisition' was crucial to the eventual success of agriculture as a food production system and often involves processes that are quite interesting in their own right.

In the south-western United States, foragers began to cultivate maize shortly before 1000 BC, according to the best available evidence (Wills 1988:149), clearly deriving the domesticated plants from Mesoamerican sources further south. Early maize was a subtropical plant not well suited to the Sonoran desert, and its adoption by the mobile foragers of this region did not at first result in a radical transformation of society. 'The initial introduction of domesticated plants in the Southwest was a monumental non-event with little *immediate* impact on native human populations' (Minnis 1985:310). It was not until much later, in the first millennium AD, that the inhabitants of many parts of the south-western United States came to depend on maize as their primary food source. Wills (1988) has advanced the hypothesis that the initial adoption of maize was an effort by foragers to alter their pattern of seasonal movement in order to spend more time in rich upland zones to monitor and exploit the wild resources there. In other words, in Wills's view, the introduction of agriculture to this region was to sustain and enhance a foraging system.

A similar situation existed in north-central Europe, in northern Germany and Poland, Denmark, and the Netherlands, shortly before 4000 BC (Bogucki 1996). Domestic plants and animals had been present just to the south in the areas colonized by the Linear Pottery culture for at least a millennium, yet they were not immediately adopted by the foraging populations of the northern European lowlands. These foraging populations, particularly in coastal regions of Denmark, Germany, and the Netherlands, exploited a rich environment with abundant terrestrial and marine resources (Price and Gebauer 1992). Several hypotheses have been offered to explain why the foragers in various parts of north-central Europe adopted agriculture, including imbalances between populations and resources caused by environmental change (for example: Larsson 1986; Rowley-Conwy 1985) and competition for prestige necessitating surplus production (Jennbert 1985). Price *et al.* (1995:125) note that in southern Scandinavia there seems to be no evidence of population pressure or climatic change directly involved in the adoption of domesticates, which suggests that social competition and demand may have been the primary factors.

A common theme in studies of 'primary crop acquisition' is that the mere *availability* of domesticated plants and animals did not lead immediately to their adoption by foraging populations (Zvelebil and Rowley-Conwy 1984). In both of the cases mentioned above as well as elsewhere, for example in southern Africa (Hitchcock and Ebert 1984), the presence of neighbouring populations practising agriculture did not demonstrate the 'superiority' of food production. Instead, there is normally a significant time lag between the moment a population becomes aware of food production and the eventual integration of domesticated plants and animals into its own subsistence economy. The challenge for archaeologists, then, is to understand *why* foraging populations choose to practise food production, but the answer to this question, as was the case with 'pristine domestication', is often elusive.

AGRICULTURAL COMMITMENT

The adoption of domesticated plants and animals was not the end of the transition to fully agricultural societies. Welch (1991), paralleling Bronson's (1977) comparison of 'cultivators' and 'farmers', has made the crucial distinction between, on the one hand, the initial use of domesticates, integrated into an economy similar in other respects to the preceding one based on foraging, and on the other, the *commitment* to agriculture reflected in the full linkage of human behaviour—economic, social, even ritual—with the maintenance of the agro-ecosystem and its production of reliable harvests. The commitment to agriculture represents the final step in the transition from one set of premisses on which society is organized to another. In the Levant, for instance, the domestication process itself, and the onset of cultivation, appears to have taken place relatively rapidly (Bar-Yosef and Belfer-Cohen 1992). On the other hand, the commitment to agriculture, with the establishment of communities that were specifically adapted to the maintenance of an agro-ecosystem, seems to have taken place more slowly over 2,000 years (Byrd 1992). By contrast, in the south-western United States, after a long period of practising mixed horticulture (gardening, hunting and collecting), communities rapidly made the transition to sedentary life structured around sustainable agriculture (Welch 1991).

Considerable archaeological research has been dedicated to the documentation of the initial appearance of cultigens and domestic animals, while much less has been devoted to the shift to committed agriculture. Yet the eventual dependence on agriculture is not simply the inevitable result of the initial use of domestic plants and animals. It is the product of a further set of choices, decisions and responses which resulted in fundamental organizational changes in society (Hodder 1990; Whittle 1996). In both regions of 'pristine domestication' and of 'primary crop acquisition', most prehistoric populations eventually crossed the threshold of commitment to agriculture. The discussion below focuses on some of the issues that faced societies which have crossed this threshold.

SEDENTISM AND OPTIONS

A significant correlate of the transition to an agricultural economy is sedentism. According to Kent (1989:2), sedentism is the opposite of nomadism along a continuum of mobility. In other words, if nomadism represents the movement of a group on a landscape, sedentism is the lack of such mobility. Of course, no human group or community is entirely sedentary, just as none is absolutely nomadic. All fall between the two extremes on this continuum, although for classification purposes they can be characterized as one or the other depending on which state of mobility or non-mobility is most prevalent. Although it is not possible to say that there is a causal relationship between agriculture and sedentism (Rindos 1984:173), it is clear that agriculture can *change* patterns of mobility and residence.

The transition to agriculture, specifically by the establishment of fixed locations where crops grow, forces a group to reconcile its patterns of mobility with the demands of the agricultural system. Rindos (1984:176) terms this reconciliation *agrilocality,* as it represents a dynamic interaction between human locational strategies and the demands of a new agricultural system. It would be wrong to say that agriculture is incompatible with mobility or that sedentism is restricted to agriculturalists. Indeed there are many known groups who are not completely sedentary who grow crops. In Massachusetts in the seventeenth century, for example, the Wampanoag tribe maintained winter inland settlements and summer coastal settlements, where crops were raised (Williams [1643]1973: for a critical review, see Bragdon 1996). In the Amazon drainage, a number of horticultural groups could be categorized as semi-sedentary, the best known being perhaps the Siriono of Bolivia (Holmberg 1969). Some Kalahari hunter-gatherers combine food production and a nomadic way of life (Hitchcock and Ebert 1984). None the less, the fact that agriculture represents an investment of effort and time, however minimal, in a fixed location, causes a society that incorporates some measure of mobility into its residential pattern to confront the question of whether it can continue its nomadic mobility patterns to the degree hitherto practised.

For nomadic societies, mobility provides a variety of options for adjusting conflicts and imbalances: in scheduling, in resource availability, in population, in social transactions. Increasing sedentism, or lack of mobility, implies that the options afforded by mobility would also decrease. Alternative structures would need to be developed to resolve the same imbalances. In large measure, the social and economic consequences of the transition to agriculture revolve around the decreasing options afforded by mobility and the elaboration of alternative structures for addressing conflict and imbalances: storage, exchange, social structure, ritual, warfare.

Sedentism also represents a shift in the human approach to territoriality and time (Carlstein 1982). It also permits the accumulation of material possessions and enhances conditions for population growth. These factors, however, open the door to further challenges posed by increasing complexity in social and economic structures, which Johnson (1982) has called ‘scalar stress’. One solution would be to invoke the remnants of the mobility option, as settlements fission and relocate. Another would be to elaborate extramural ways of addressing imbalances, such as trade and warfare.

LABOUR

Among small-scale agriculturalists in the world today, land, labour and capital form the elements of the productive system, and their control is the basis for access to status, power and wealth. Early agricultural societies are generally considered to be ‘pre-capitalist’ in the sense that they did not have the conditions under which productive assets constituted capital and there was not a category of people who earned their living solely from the accumulation and exchange of such assets. Thus, land and labour are usually considered to be the critical factors in determining the productivity of agricultural systems such as those which would have been found in the first several millennia following the transition to agriculture. Today, in most parts of the world, ability to acquire land is viewed as the primary limiting factor on subsistence production, yet for most early agricultural societies it is likely that arable land was relatively abundant in absolute terms. Although optimal habitats might have soon been thoroughly settled, adequate amounts of arable land on lesser-quality soils or in otherwise suboptimal habitats would have been available. Instead of land, labour supply was probably the major limitation on early agricultural production (Bogucki 1988).

There are periods in the agricultural cycle, such as land clearance, planting, weeding and harvesting, which require considerable amounts of labour, but over relatively short periods of time. Such periods are typically referred to as 'labour bottlenecks' (Jaeger 1986:7; Richards 1985:68). The agricultural community must balance its labour requirements for these bottlenecks against its ability to support this workforce over the remainder of the agricultural year. Generally, a compromise results which constrains the overall productivity of the subsistence system, perhaps in terms of the amount of land it can bring under cultivation or the degree to which fields can be weeded. Labour, then, is a very inelastic resource, which limits the ability of an agricultural community to produce both for its own survival and for accumulation and exchange.

Along with sedentism, the transformation of the mobilization and control of labour was an important structural change that accompanied a commitment to agriculture. Societies which were still largely based on foraging with some cultivation would not have needed to make many adjustments to accommodate labour bottlenecks. Once a society was primarily dependent on agriculture and animal husbandry, however, the size and structure of the labour pool would have been a primary determinant of agricultural productivity. It is possible, then, to see limitations on labour, particularly at the bottleneck times, as a factor in the eventual development of innovations which permit human energy to be invested

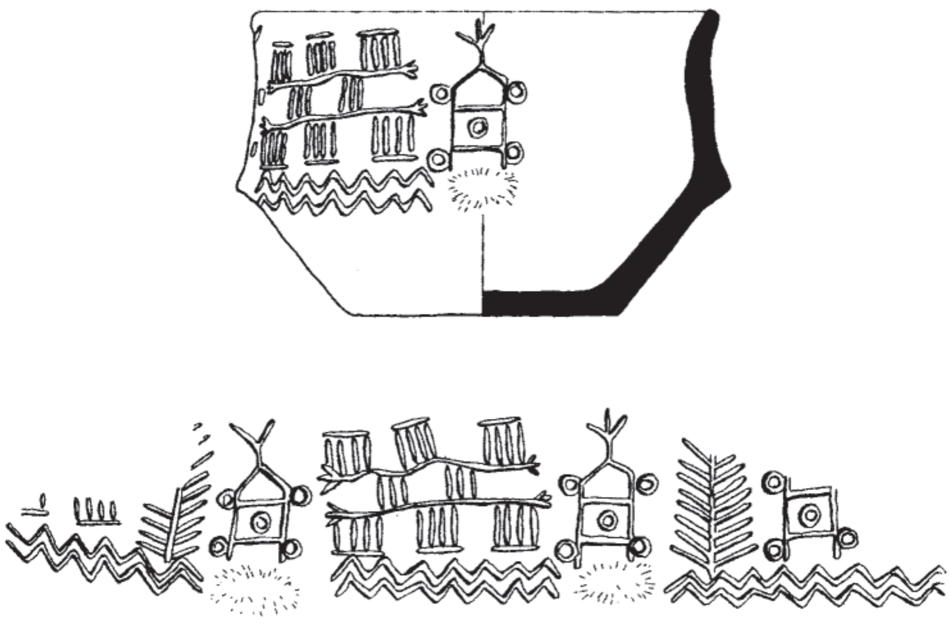

Figure 21.6 Representation of a wagon on a vessel from Bronocice, Poland, dated to the fourth millennium BC, indicating an early use of animal traction for cartage. Source: Milisauskas and Kruk 1982.

in agriculture in other ways to increase the productivity of a parcel of land (see, for example, Bogucki 1993). Such innovations would include animal traction for ploughing and cartage (Fig. 21.6), irrigation and raised fields, and manuring. The management of livestock and the digging of irrigation ditches clearly involve human labour, but these can be done mostly at times other than those of the labour bottlenecks that constrain the productivity of agriculture.

HAZARDS, RISKS AND UNCERTAINTY

Agriculturalists must constantly make decisions, the consequences of which they must predict, on the basis of available information, experience and intuition. In this process, the farmer must make some assessment of the range of potential outcomes. Economists and ecologists have recently taken an interest in the fact that farming decisions are not made on the basis of complete certainty. Instead, agricultural decision-makers must incorporate some consideration of the unknown, the random, and the unpredictable into their behaviour, which in turn determines how they respond to their environment. An ideal world of full information and complete certainty bears little resemblance to the conditions under which human groups operate. Instead, we must recognize that prehistoric societies did not have complete information about their environment or ways to predict random environmental hazards.

The environment of early agricultural groups had considerable potential for hazards and stress. Hewitt (1983) has pointed out that the removal of domesticated plants from their original habitats increased their vulnerability to hazards. The subsistence system of agricultural peoples is based on an artificial association of plants and animals that can be maintained only through human intervention. As such, it is inherently unstable and prone to fluctuations of environmental conditions—rainfall, sunlight, insects, diseases—and changes in the ability of human groups to invest the labour required to maintain fields and livestock (Fig. 21.7). We cannot simply assume that these variables can be eliminated from consideration and still hope to develop models that accurately explain the archaeological record.

Economists and ecologists identify two important conditions under which decisions can be made: risk and uncertainty. This distinction was first made by the economist Frank Knight in 1921, but since then there has been little consensus about the dividing line between risk and uncertainty, or whether the two concepts can be separated at all. Knight differentiated between *risk,* in which probabilities could be assigned to a range of known outcomes, and *uncertainty,* in which an absence of information or predictive data made the range of outcomes unknowable. Some economic anthropologists have argued that this distinction is useful in dealing with small-scale agrarian societies. Cancian, for instance, noted that there are differences between how farmers take account of known environmental variation

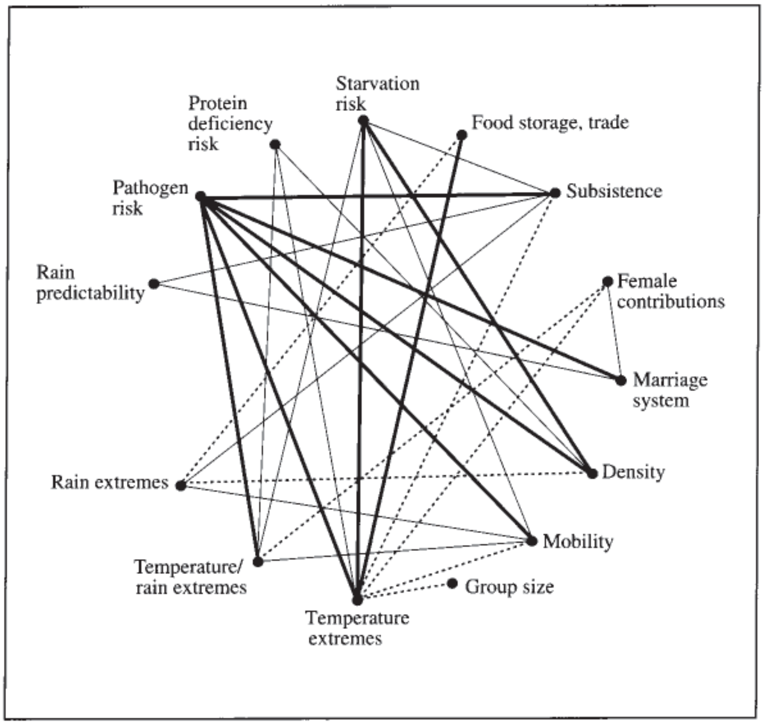

Figure 21.7 Relationships among critical variables of risk and uncertainty. According to Low's analysis, heavy lines indicate at least one relationship of $p < 0.001$ or more than one relationship of $p = 0.01$; light lines indicate at least one relationship of $p = 0.01$, or more than one of $p = 0.05$; dotted lines indicate at least one relationship of $p = 0.05$. Source: E.Cashdan, redrawn by D.Miles-Williams.

such as rainfall in their decision-making and how they deal with the unknown results of new technology (Cancian 1980). Others have maintained that this distinction is artificial, for 'probabilities of future events are never "known" with complete certainty' (Berry 1980:325).

Social scientists recognize several components of risk (Merkhofer 1987). First, there must be a source of risk, a *hazard*. Second, there must be a process by which people and their property are *exposed* to the hazard. Third, there must be a process by which the exposure produces adverse results. The *perception* of the risk by individuals and groups involves a further process that incorporates an evaluation that the severity or inequity of the adverse results is sufficient to be of concern. This final process of risk perception is generally subjective, but none the less constitutes a probability judgement about the frequency or likelihood of an unpleasant event.

How do farmers reduce risk? One way is to subdivide and thus multiply the number of units (fields or crop varieties, for example) exposed to hazards. Rather than have one large field on a single soil type, farmers can have a number of small fields on a variety of soil types. The trade-off for this is a loss of efficiency in travel and scheduling, but if the probability of environmental hazard is judged sufficiently high, such a cost might be acceptable. Another diversification strategy is to grow a variety of different crops that respond differently to climatic variation (see, for example, Halstead and Jones 1989). Minnis (1996:62–64) points out that the use of low-preference foods, or 'famine foods', which are neglected in times of plenty, constitute yet another form of diversification. Storage can also be viewed as a response to risk (Bettinger 1991). Finally, the establishment of reciprocal exchange relationships with other individuals and households can be viewed as a form of insurance which spreads the exposure to hazard over a number of units (Cashdan 1985).

The position taken here is that the distinction between risk and uncertainty can provide an important insight into different patterns of prehistoric behaviour. Calavan (1984), for instance, points out that farmers, in making production choices, operate differently under these two conditions. Farmers producing a long-established crop with a familiar and traditional technology will obtain yields that will vary from year to year but within predictable limits. Based on their observations of environmental conditions, they can allocate subjective, but reasonably accurate, probabilities to these yields, and base their investment of labour and time accordingly. In such a circumstance, farmers operate under conditions of risk. On the other hand, farmers who are trying a new technology or a new crop, or who are colonizing new environmental zones, will find themselves in a situation where the yields cannot be predicted with confidence. While such innovation can pay off richly if the guess is correct, it can also be catastrophic if the farmer guesses wrong in allocating his resources. In this situation, the farmer operates under conditions of uncertainty. Such uncertainty can be turned into risk through experience and learning, although this may take several generations for knowledge of the range of possible outcomes to accumulate.

The question of innovation is another important dimension of early agriculture. Studies of subsistence farmers today show that they are avid experimenters (Richards 1985), and there is no reason to believe that prehistoric farmers were not equally prone to experimentation. Innovation is closely linked with risk and uncertainty (Cancian 1979; van der Leeuw 1989), particularly in situations where there is pressure from external sources on the agricultural economy to increase production. When does the need to increase production offset the risks involved in new and untried methods? This brings us to yet another critical issue in the study of small-scale subsistence agriculture—that of *intensification*.

INTENSIFICATION

Intensification can have a variety of meanings and connotations for different researchers, and it is important to be explicit about what the term actually means. A broad definition is offered by Brookfield (1972:31), who defines it as 'the addition of inputs up to the economic margin', the margin where the application of further inputs will not increase total productivity. The inputs can take a variety of forms. Anthropologists have tended to concentrate on raw labour inputs and 'skills' as easily quantifiable and indexed dimensions of intensification, but Brookfield emphasized that there are many other components to consider, including organization of labour and structure of land use (1972:32).

A somewhat narrower concept of intensification has been used by other anthropologists and economists who have studied agricultural societies (for example: Boserup 1965; Conklin 1961). Their definition of intensification is focused on the length of the fallow period, the time in which fields lie unplanted, with the degree of intensification inversely correlated with the length of the fallow. While narrower in scope, such a definition of intensification is related to that proposed by Brookfield in that a shorter fallow period usually demands an increase in labour and related inputs per plot.

Most archaeologists who employ the concept of intensification come to it via the so-called 'Boserup hypothesis', which links intensification to population growth. Boserup argued that agriculture will be intensified, by shortening of fallow length and the introduction of the plough and irrigation, as population increases. Since settlement sizes and distribution are believed by many archaeologists to be reliable proxy indicators of population increase, the causal relationship between population growth and intensification is attractive. We have already discussed how the Boserup model was extended to form the basis for some of the prevalent 'push' models for the origin of agriculture, and it also forms the theoretical rationale for many attempts to explain changes in early agricultural societies as well.

The expression of intensification only in terms of fallow length and as strictly related to population growth is but a limited version of a much broader process that can touch society in many other ways. For instance, the dispersal of settlements to minimize travel time to and from fields and the integration of animal traction into the household economy can be viewed as intensification strategies, even though they do not involve the direct input of labour into agricultural work. Bogucki (1988, 1993) has argued that both of these were employed in the fourth millennium BC in Europe to intensify the agricultural system. If this is the case, then there are clear implications for the social and economic relationships implicated in a change in settlement pattern and the investment in assets such as draught animals. Moreover, an equally plausible trigger for agricultural intensification is constituted by changes in social relationships that make demands on the subsistence system for greater production of materials to be used in social transactions (Bender 1978; Nassaney 1987).

Intensification is not a unilinear process, and there are examples known from the ethnographic record of shifts from more to less intense levels of land use, referred to as 'deintensification' (Guillet 1987) or 'disintensification' (Brookfield 1972). While in many cases these examples can be correlated with population shifts, their existence suggests that intensification is dependent on a number of factors besides raw population size or its rate of change. One interesting issue is the relationship between intensification and agricultural risk. For example, Nichols (1987) has argued that the emergence of intensive irrigation agriculture in the Basin of Mexico was a response to the risks posed by annual variation in water supply. In her model, intensification occurs before there is an imbalance between population and resources. The implication of this model is that if the source of risk were to dissipate (which would be unlikely with populations, unless they moved away), then there is at least the theoretical possibility that the process of intensification could be arrested or even reversed.

FORAGERS AND FARMERS

The adoption of agriculture around the world was not instantaneous, of course, or even inevitable. Food-producing populations have often lived in proximity to human groups for whom farming and herding had little importance. Moreover, the adoption of agriculture is not a one-way street, and it is possible for groups to decide to give up sedentary farming life if conditions allow them to do so. Even among populations that were fully committed to agriculture, such as those of medieval and early modern Europe, gathered foods played an important role in the diet.

Ingold (1984:5) has noted that anthropologists have the tendency to remove people from the category of foragers if they have any attributes of agriculture or pastoralism. There are really, however, four basic categories of human groups in terms of subsistence systems: (1) those who subsist on uncultivated plants and wild fauna—foragers; (2) those who have a mixed subsistence economy, based partly on domestic and partly on wild resources: these can be subdivided further into two sub-categories, (2a) foragers who farm (yet still closer to category 1), and (2b) farmers who hunt (yet still closer to category 3); (3) those who gain no significant subsistence from uncultivated plants or wild fauna—agriculturalists and pastoralists. In general, anthropologists have tended to view the universe of human subsistence economies as a binary set: those in category 1 and those in category 3. The root of the problem may be that the colonization of Africa, the Americas, Australia, and the Pacific in the eighteenth and nineteenth centuries essentially 'froze' many societies as either foragers or food producers depending on their circumstances at the time of European contact. The point of this frozen moment was then assumed to be fixed on the unilinear scale of progress from hunting and gathering to farming and stock-herding. Early anthropological studies that were based on short-term contact tended to reinforce this viewpoint. Yet all does not seem to be so simple. Long-term studies of a number of groups reveal fluctuations between foraging and farming with an annual or even longer periodicity.

There is a prevailing belief among anthropologists that once a society heads down the road to agriculture it cannot return. In general, it is widely believed that once population growth occurs as a result of the 'improved' food supply brought about by food production, the society comes to depend more and more on its crops (for example, Cassidy 1980). Actually, there is little evidence to suggest that population growth is an automatic effect of the adoption of agriculture, and it appears that even among agricultural societies there are mechanisms that restrain population growth and fertility (see, for example, Englebrecht 1987 for a discussion of this among the Iroquois). It is entirely possible for societies at this boundary between foraging and farming to slide back and forth from one strategy to another, following one for a few years, then reverting to the other, and back again. For instance, the Agta in the Philippines, long thought to be prototypical hunter-gatherers (Peterson 1978a, 1978b), actually are opportunists who make use of the subsistence strategy that best suits the conditions of the moment (Griffin 1984).

These conditions can be determined both by the natural environment and by the sort of interactions that a group is having with agricultural neighbours at any given moment. In studying the dispersal of agriculture beyond areas of 'pristine' domestication, archaeologists have begun to draw on comparative ethnological studies of forager-farmer interaction and to propose models for such interaction in prehistory (for example: Bogucki 1995; Gregg 1988). Often these involve the exchange of hunted or collected resources from the foragers for cultivated products of farmers, although the potential of forager populations for providing agricultural labour cannot be underestimated. The study of such forager-farmer interactions holds great promise for the understanding of the spread of food production, particularly in cases where foragers adopted domesticated plants and animals from nearby farming populations.

CONCLUSION

The establishment of sedentary agricultural communities in both the Old World and the New World laid the foundation for subsequent changes in human society. It is important to realize, however, that despite the rise of urbanism and state societies in some regions, rural agrarian communities have continued in a way of life that had its roots millennia earlier. Farmers continue to make decisions about how to allocate land and labour under conditions of risk and uncertainty. Agrarian societies respond to needs and challenges by intensifying their production. Although a tractor can be substituted for oxen, and cultigens can be selected and improved, farmers seek the same opportunities and work under the same basic constraints today as did their counterparts millennia ago.

The two most significant changes in agriculture in the last several millennia have been the emergence of cash-cropping, in which choices are determined by market concerns rather than nutritional needs, and the global dimensions of agriculture. A potato farmer in Poland today worries about the productivity of an Andean domesticate, while the plains of the central United States are covered by fields of wheat first domesticated in the Levant 10,000 years ago. Pigs in Iowa, descended from animals first domesticated in Anatolia in the seventh millennium BC, are fattened on maize, domesticated in highland Mexico. Considered in this light, the origins and, just as importantly, the dispersal of food production as a successful economic strategy have truly shaped human existence for the last ten millennia.

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The last decade has seen a proliferation of books which discuss the transition from foraging to farming and early agricultural societies. This is probably the ultimate result of the concentration of archaeological field research on this problem in the 1970s and 1980s. For comprehensive overviews of the botanical and zoological basis for early domestication, the basic sources remain Harris and Hillman (1989) and Zohary and Hopf (1993) for plants, and Glutton-Brock (1989) for animals. Harlan's *The Living Fields* (1995) is a memoir of a remarkable botanical career which includes reflections on the current status of the study of agricultural origins. Archaeological anthologies of articles discussing the transition to agriculture include Watson and Cowan (1992), Gebauer and Price (1992) and Price and Gebauer (1995). A highly readable, single-author treatment of agricultural origins is Smith's *The Emergence of Agriculture* (1995). Stark's 1986 article is a classic discussion of the models used to explain agricultural origins and remains widely cited a decade later. Regional studies of early agricultural societies are fairly numerous and include Smith (1992) for the eastern United States, Wills (1988) for the south-western United States, and Bogucki (1988) and Barker (1985) for Europe. An up-to-date synthesis of agricultural origins in Mesoamerica has yet to appear. Discussions of issues such as labour, risk, and uncertainty in early agricultural societies are relatively rare, but examples include Bogucki (1988), Wills (1988), and papers in Tainter and Tainter (1996).