

FORAGING AND FARMING

The evolution of plant exploitation

Edited by
David R. Harris and Gordon C. Hillman

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Foreword

This book is one of a major series of more than 20 volumes resulting from the World Archaeological Congress held in Southampton, England, in September 1986. The series reflects the enormous academic impact of the Congress, which was attended by 850 people from more than 70 countries, and attracted many additional contributions from others who were unable to attend in person.

The *One World Archaeology* series is the result of a determined and highly successful attempt to bring together for the first time not only archaeologists and anthropologists from many different parts of the world, as well as academics from a host of contingent disciplines, but also non-academics from a wide range of cultural backgrounds, who could lend their own expertise to the discussions at the Congress. Many of the latter, accustomed to being treated as the 'subjects' of archaeological and anthropological observation, had never before been admitted as equal participants in the discussion of their own (cultural) past or present, with their own particularly vital contribution to make towards global, cross-cultural understanding.

The Congress therefore really addressed world archaeology in its widest sense. Central to a world archaeological approach is the investigation not only of how people lived in the past but also of how, and why, changes took place resulting in the forms of society and culture which exist today. Contrary to popular belief, and the archaeology of some 20 years ago, world archaeology is much more than the mere recording of specific historical events, embracing as it does the study of social and cultural change in its entirety. All the books in the *One World Archaeology* series are the result of meetings and discussions which took place within a context that encouraged a feeling of self-criticism and humility in the participants about their own interpretations and concepts of the past. Many participants experienced a new self-awareness, as well as a degree of awe about past and present human endeavours, all of which is reflected in this unique series.

The Congress was organized around major themes. Several of these themes were based on the discussion of full-length papers which had been circulated some months previously to all who had indicated a special interest in them. Other sessions, including some dealing with areas of specialization defined by period or geographical region, were based on oral addresses, or a combination of precirculated papers and lectures. In all cases, the entire sessions were recorded on cassette, and all contributors were presented with the recordings of the discussion of their papers. A major part of the thinking behind the Congress was that a meeting of many hundreds of participants that did not leave behind a published record of its academic discussions would be little more than an exercise in tourism.

Thus, from the very beginning of the detailed planning for the World Archaeological Congress, in 1982, the intention was to produce post-Congress books containing a selection only of the contributions, revised in the light of discussions during the sessions themselves as well as during subsequent consultations with the academic editors appointed for each book. From the outset, contributors to the Congress knew that if their papers were selected for publication, they would have only a few months to revise them according to editorial specifications, and that they would become authors in an important academic volume scheduled to appear within a reasonable period following the Southampton meeting.

The publication of the series reflects the intense planning which took place before the Congress. Not only were all contributors aware of the subsequent production schedules, but also session organizers were already planning their books before and during the Congress. The editors were entitled to commission additional chapters for their books when they felt that there were significant gaps in the coverage of a topic during the Congress, or where discussion at the Congress indicated a need for additional contributions.

The origin of this book was a two-day symposium at the Congress on the theme of 'Recent Advances in the Understanding of Plant Domestication and Early Agriculture', which was organized under four major headings. The first, on 'Plant Gathering and Manipulation by Non-Agricultural (Hunter-Gatherer) Peoples and the Plant Component in their Diet' lasted for more than half a day, and was itself subdivided into two sessions, on 'Ethnobiological and Archaeological Perspectives', and on 'Defining, Observing and Explaining Domestication'. The rest of the first day was focused on 'Plant Domestication and Early Agriculture in Western Eurasia', discussion being split between 'Early Plant Exploitation and Cultivation in Southwest Asia' and 'The Beginnings of Agriculture in Europe'. The first part of the second day's meeting considered 'Plant Domestication and Early Agriculture in the Indo-Pacific Region', divided into 'Mainland South and East Asia' and 'Island Southeast Asia and the Pacific', with the second part of the day being devoted to discussion of the Americas, by focusing successively on 'Domestication and Diffusion of Seed Crops', 'Domestication of Tuberous Crops' and 'Emergence and Intensification of Agriculture', and concluding in the evening with a lively discussion of general themes arising from the symposium as a whole.

The original choice of the overall theme derived from the conviction that it was again timely to consider the processes of plant domestication by human beings, most particularly from as wide a world-view as possible. Very early on it became evident that to do so in a meaningful way – given that studies of plant domestication, and particularly archaeobotanical studies, have multiplied rapidly in recent years – would mean separating the discussions of plants and animals, despite the traditional inclusion of crops *and* livestock in the 'Neolithic Revolution'. The exploitation and domestication of animals is in fact considered in another book in the *One World Archaeology* series, *The walking larder* (edited by J. Clutton-Brock).

The organization of the symposium on plant domestication and early agriculture kept, perhaps more closely than any other thematic discussion, to the original intention behind the (expensive and time-consuming) circulation of pre-Congress full-length papers to all potential participants in the symposium. This aim was achieved, and all discussion was therefore based on the expectation that papers had been read and digested before the meeting. As a consequence, no papers were read out by authors and the 18 hours of meeting were devoted to intense discussion and debate. Such a mode of conference organization is difficult to achieve but, when it does occur, the results are not only enormously worthwhile but they achieve a level of informed interchange unique to such a format. A successful meeting of this kind not only relies very heavily on the prior preparation of those chairing sessions, and on the quality of previously chosen section discussants, but it also converts writers into active participants.

The main themes explored and exemplified in *Foraging and farming* are outlined in the editorial Introduction (pp. 1–8). My aim in what follows is to examine a few of the points that have struck me personally as being of particular note or fascination.

Foraging and farming, quite apart from many other virtues, successfully reflects much of the excitement and cohesion of the symposium itself (and see Harris 1987). Many of the individual chapters have been cross-referenced by the editors and refer to other contributions in the volume, and the result is a uniquely coherent approach to the fascinating and complex problems with which the book is concerned. Much of the excitement with the subject which the book conveys derives from the realization that this area of archaeological enquiry has become even more interdisciplinary than before, and that new approaches to the material and processes under consideration have not only shattered some long-held assumptions but have important implications for our overall understanding of human social and cultural developments.

Examples of new discoveries abound in this book, but one of the most dramatic must be the realization that agriculture was already practised in the Waghi Valley in the Papua New Guinea Highlands some 9000 years ago, and that by at least 6000 years ago swamps in the valley were being drained in order to cultivate root crops such as taro. A world perspective, as demonstrated in *Foraging and farming*, removes attention from the traditional European preoccupation with attempting to discover where and when an assumed 'original' discovery of plant cultivation and domestication first took place. Instead attention shifts to attempts to understand the social and environmental circumstances which must have led to the independent adoption of plant cultivation and domestication at different times in different parts of the world. At about the same time that agriculture was being practised on the hillsides of the Waghi Valley, plants were being cultivated in the Andean Highlands of Peru. Such early dates for cultivation and agriculture in different parts of the world draw attention to the ecological skills and manipulative attainments of hunter-gatherer societies: a theme that is very fully explored and discussed in this book. Refreshingly, *Foraging and*

farming does not accept the popular myth of today that all hunter-gatherer societies have lived in a utopia of easy self-sufficiency (for example, in the Panamanian tropical forests).

Not surprisingly, *Foraging and farming* has to contend with problems of definition. It sets forth many arguments in favour of modifying existing usages. These are not merely semantic arguments, of little real value. They are necessary attempts to match our vocabulary to the complexities, and new understandings, of the practices which were, until recently, often lumped together under the undifferentiated (partly chronological and partly developmental) term 'Neolithic'. That this term hid a diversity of human, plant, and animal behaviour was already clear in 1968 when, with Geoffrey Dimbleby, I edited a book with somewhat similar aims to this one (Ucko & Dimbleby 1969), but – however seminal that book may have been at the time – it is now evident that to classify a culture as 'Neolithic' only has useful meaning when developed agriculture and a sedentary way of life have become well established. An appreciation of the potential complexity of developed agriculture is gained from some of the contributions to *Foraging and farming*, for example, in the discussion of Maori gardens and of early agriculture in the American Midwest. However, even prior to the adoption of sedentary life, human societies already manipulated and used plants in a great variety of different ways.

Discussion of such variety leads inevitably to fundamental questions regarding the relative influences of natural and social selection, in a Neo-Darwinian (or sociobiological) sense, and of the vagaries of human choice in creating variety and development. Both views are advanced in this book and both raise important questions about the adequacy of current anthropological and archaeological models which attempt to explain innovation and change in human societies (see *What's new?*, edited by S. Van der Leeuw & R. Torrence). Whichever approach is favoured, there is no doubt that the complex process of plant domestication receives new scrutiny in this book. It is the combination of redefinition and reanalysis of existing assumptions that makes the book so evidently a threshold to further theoretical advances in the discipline. Conceptualizing plant domestication in processual terms, rather than as a historic 'event', creates its own new insights. One of the most striking is the realization that the fact that Australian Aborigines did not adopt agriculture (in the strict sense) does not in any way imply a lack of understanding of, or a capacity to modify, the ecology of the plants around them. Indeed, the hunting and gathering Australian Aborigines 'domesticated' the environment, *including plants*, *not* by practising agriculture but by developing a complex system of mental categorizations which gave them control over their plants (and animals). In this sense, as is emphasized in *Foraging and farming*, the actual domestication of plants is a relatively late form of manipulation of the environment and not one which is necessarily always adaptively advantageous in the long term (see *Pleistocene perspective*, edited by A. M. ApSimon & S. Joyce). This conclusion can be seen to be true in different ways; for example, it may be easier to *ritually* control food

sources (and to explain failure in this way) by carrying out appropriate ceremony, rather than to be subject (as is the farmer) to unpredictable fluctuations of climate and changes in soil fertility; or to harvest wild plants when it is more energetically cost-effective than to grow them.

Many of the contributions appear, at first sight, to be determinedly scientific, both in methodology and in interpretation. Indeed, many of the new developments in the study of plant exploitation and domestication derive from the application of rigorous techniques of archaeological investigation and interpretive analysis. Advances in the subject depend as much on the secure identification of plant remains – often below the species level – as on accurate dating and the correct characterization of cultural contexts. Nevertheless, *Foraging and farming* also exemplifies how social and cultural factors can never, and *should* never, be entirely divorced from the formulation of hypotheses and the strict application of scientific techniques. For example, even after the most exhaustive analyses the ‘scientific’ conclusion that a paste is toxic may, or may not, be the essential factor relevant to explaining its use in a society which may in fact choose to associate it with the *spiritually*-induced actions of vomiting and hiccuping. Such dilemmas of interpretive emphasis – conventionally thought of as respectively etic and emic – remain tantalizingly in the wings of explanation. Now, however, the indigenous ideologies of the societies which took up ‘agriculture’, or chose to ‘reject’ such ‘innovations’, are recognized as essential ingredients of the data base from which interpretations must derive. Can it have been factors such as culture-specific and presumably subjective judgements about the pleasant taste of some wheats as opposed to others, which may have led humans to species-specific exploitation and the neglect of additional or alternative grasses? Is it possible that the cultural and symbolic role of certain non-edible gourds in demonstrating age, seniority, and status (Ucko 1969) through the wearing of specially trained gourds as penis sheaths was the kind of influence which may have preceded the explicitly economic exploitation of these plants?

Consideration of such cultural matters represents a striking departure from other scientifically-oriented books. For these reasons, perhaps *Foraging and farming* foreshadows a book, in another twenty years’ time, which will be more sophisticated in its treatment of concepts such as social or biological ‘selection’ and social and cultural ‘stability’ or ‘complexity’, and which will be even more concerned with ethnoclassification than is the present volume. For the first time in the history of the subject this volume is really able to approach the previously untrodden, and immensely difficult, path of investigation and explication which must attempt to assess the relative importance of the inward-looking ‘emic’ attempts to understand and classify, as opposed to the comparative ‘etic’ systems of classification which are based on assumptions about ‘development’ and ‘evolution’. Despite its explicitly evolutionary subtitle, this book brings much nearer the moment when conventional archaeological assumptions about what social and cultural messages can legitimately be assumed to be incorporated in the so-called

'continuity' of religious belief or 'continuity' of art styles (see *The meanings of things*, edited by I. Hodder, and *Animals into art*, edited by H. Morphy) will receive new challenges from the direct bioarchaeological evidence of plant (and animal) exploitation. Already, in this book, the glimpses into the complexities of emic explanatory systems and ethnoclassification show that, in the future, our analytical terminologies will have to be further refined to cover all aspects of the harnessing of plants to human social endeavour. Plant processing, for example, is an immensely complex affair associated with many different social practices which explanatory models based on assumptions of economic maximization appear unable to accommodate. It is becoming more and more evident that plants may have been manipulated for many reasons, varying, for example, from the provision of fodder for stock (Southwest Asian legumes), to attempts to better understand the ancestors (maize). It is also clear that humans may not always have been the primary or sole agents of change. In the case of Andean maize, for example, it is argued that birds may have been the first to spread the wild plants, with humans only coming in on the act subsequently.

Foraging and farming will long remain in the forefront of attempts to bring the evolutionary/ecological and the cultural into a satisfactory intellectual relationship. It demonstrates forcibly that complexity is not confined to the biology and ecology of the plants themselves, but is at least equally evident, and significant, in the social conditions which affect the cultural classification not only of the plants but also of matters of 'taste' and eating behaviour.

The nature, and almost certainly the degree, of involvement of people with particular crops and, therefore, whether or not they were essential components in the migrations of peoples from one area to another, appear to be intricately linked with social choices and conventions, such as the perceived palatability of particular plants, or their perceived suitability for technological processes such as dyeing. Whether or not such cultural attitudes are corollaries of actual usage, or should be seen as *post hoc* rationalizations of existing practice, remains one of the most intriguing questions implicitly posed in several chapters. Only when further consideration has been given to these questions will we be able to do more than note the very elaborate systems which different societies employ to classify the plants in their environment. Only in the future will we be able to assess the implications, for any economic agricultural activity, of some societies employing quite gross classifications of plants, while in others the cultivator is said to know (and be able to name) each plant in his field.

This book, as already suggested, moves onto the offensive in its re-evaluation of the role of hunter-gatherer societies in the manipulation of plants. This is perhaps the single most important shift in emphasis since the publication in 1969 of *The domestication and exploitation of plants and animals*. At that time it was still commonly assumed that once the advantages of agriculture had been realized about 7000 years ago somewhere in the Near East, it was somehow inevitable that all hunter-gatherer societies within the region (and beyond) would move over to an agriculturally based economy.

The prevailing model of the 1960s was based on the concept of an essentially static and receptive group of human beings, whatever their particular form of social organization. Here, in contrast, the model is a far from passive one which assumes an active role in the future activities of any group of foragers, both in their relationships to the plant resources in the environment and in their choice of how subgroups exploit those resources under varying conditions. Thus *Foraging and farming* raises many new questions about the nature of social dynamics.

It is a measure of the success of this book that almost all the conventional interpretations of the 1970s and 1980s are subjected to renewed scrutiny in its pages. Gone are the convenient assumptions so often made in the past about the presumed almost automatic effects of population and other pressures on resources. No longer can it be simply assumed that the main crop plants in Papua New Guinea must have derived from Asia. 'Static modelling' of agricultural communities, assuming them to be quite distinct from hunting-foraging ones, now appears unsatisfactory; and it is clearly revealed in several examples that the interrelations of either of the above economically-defined social groups with pastoralists may have had the most profound results, both on the plant-ecological and the social options available to the cultures concerned. Reanalysis of the available information about particular plant species, and of the archaeological evidence from particular regions, also highlights the possibility of, for example, new interpretations of the number and nature of dispersals (of people and plants?) from Africa into India (see *Food, metals and towns in African history*, edited by T. Shaw *et al.*), possible diffusion routes in and around China, and the absence of any evidence for irrigation practices associated with the earliest Chinese agriculture.

Each chapter of this book reveals new information, or new results from the reanalysis of material evidence, within new frameworks of interpretation. This is part of the novelty and value of the whole volume. Within the Americas, for example, genetic studies suggest diffusionary influences within Middle and South America that are contrary to those previously deduced from more traditional archaeological evidence. Many of the complexities of analysis and interpretation based on the investigation of plant-genetic variability are especially well exemplified by the studies of maize. It is salutary to be reminded that the complexities and uncertainties of the evidence still do not allow us to determine the routes and times of the spread of the sweet potato from South America across the Pacific. It is even more important to realize that many of our interpretations of agricultural development can be transformed by the approach and preconceptions of the investigation – 20 years ago the possibility of indigenous plant domestication in the Eastern Woodlands of North America was barely conceived, and the region was regarded as one of the backwaters of world prehistory, whereas the picture now revealed is one of early and intensive cultural (including agricultural) activity. Equally, there can be little doubt that much still remains to be learned about the origins and development of New Guinea agriculture – current analyses and interpretations necessarily have to be

carried out in a sort of vacuum because we do not know the nature of the explanatory parameters which should be applied to the evidence.

The 'Neolithic Revolution' in the Near East has often been regarded as a classic example of a simple invention, followed by adoption and subsequent wide diffusion. In the 1960s interest and emphasis switched to the multiple origins of plant domestications in numerous parts of the world. This book strongly maintains the latter emphasis with, for example, fascinating reviews of the evidence for the independent beginnings of maize cultivation in and around the Andes, but it also reconsiders the evidence for the classic Near Eastern pattern of plant domestication. In this latter case, at least, it still appears likely that the domestication of plants was a relatively rare occurrence rather than a frequent event which would have been often rejected by those who could have taken advantage of the innovation (see *What's new?*, edited by S. Van der Leeuw & R. Torrence). Such an interpretation must, nowadays, be considered in the context of evidence that the human societies of the time were exercising considerable choice in the wild plant, meat, and fish foods which they chose to exploit or reject. Such re-evaluations are fundamental to this book.

It is perhaps not surprising to learn that, since 1968, an array of new techniques has been brought to bear on archaeobotanical studies, illuminating, for example, by the application of scanning-electron and phase-contrast light microscopy, such questions as the identity of tropical American starches. It is not only the application of scientific techniques which is impressive in this book but also, and surprisingly, the fact that in some contexts, such as in Indonesia, it is the record of indigenous ritual and myth which provides the best evidence for past agricultural activities. The challenges for future research remain immense, and are clearly brought to the fore in many chapters. As the evidence of plant exploitation becomes better known in all its complexities in many different parts of the world, and from many different periods of the past, so such understanding often challenges the models of social change which have frequently been applied to the more traditional archaeological data. An example of this is the processing of the *zamia* plant in Venezuela to convert it into flour. The processes involved – including pulping, allowing the plant to rot, and then cooking it – resemble those adopted widely for the treatment and preparation of manioc. This evidence is bound to rekindle interest in the mechanisms of cultural innovation, and the role that transference of techniques from one context to another may have played in such innovative developments. In some cases, the implications of the evidence presented will take many years to assimilate into new explanatory models. One such example comes from Southeast Asia where, on present evidence, it appears that the significant changes in the social system which led to the development of chiefdoms and ranking took place as a result of sedentism but without any observable changes in agricultural practice or the selection of different foods. It is exactly such details of practice and preference which challenge the conventional linkage of social development, as revealed by the archaeological data of architecture or

funerary customs, with assumed changes in the economic, and technological, basis of the society concerned.

This Southeast Asian case exemplifies a much wider switch in interpretive orientation which is to be found in several of the chapters of *Foraging and farming*, and which is likely to dominate debate for many years to come. If there are no necessary correlations between major imposed shifts in the economic or technological basis of a society and changes to a different mode of livelihood or form of social organization, then attention is again focused on the *internal* societal conditions which may have caused the human beings constituting a particular society to move, for example, from a mobile hunter-gatherer to a pastoral transhumant or sedentary way of life (or to some combination of these or other available options). However, such a focus on the internal dynamics of a society inevitably leads to a consideration of the external socio-economic conditions within which such internal choices will have been made, for no human society exists in complete isolation. *Foraging and farming* invites us to re-examine current assumptions about the nature of the external influences on societies, and the factors which may condition the viewpoints of the people involved in such interactions (see *Centre and periphery*, edited by T. C. Champion). Most important of all, perhaps, is the conclusion that the very nature of the concept of 'societal consensus' will have to be re-examined and refined, both in relation to studies of the dynamics of cultural innovation and to those undertaken in the framework of Neo-Darwinian evolutionism.

In an unexpected way we have come almost full circle, to the realization that improved understanding of the evolution of plant exploitation requires detailed knowledge of the indigenous views, and possibly even the classificatory systems, of the members of the societies who undertook such exploitation. This book contains numerous examples of the ways that such emic views may coincide with biological explanations and biologically effective ways of manipulating and reproducing plants. Thus it is tempting to imagine that the Andean example of cultural selectivity operating at the level of taste and tradition in the mixture of particular clays with particular tubers on a scale of culinary preferences – which in turn affects the choice of which tubers should be exploited (rather than their relative toxicity) – may have much wider implications for interpretations which attempt to link ethnobotanical and archaeobotanical evidence with socio-cultural developments.

It is indicative of the quite exceptional nature of this book that such a variety of critical problems and methodological issues should be raised within the pages of one cohesive volume. In addition, the diversity and the world-wide coverage of its examples is without parallel. Novelty is thus to be found on almost every page, best exemplified perhaps in the account of current experiments in the domestication of West African yams, experiments which not only cast light on how yams may have been domesticated in the past, but which also link the past to the future, through the possibilities that such experiments may offer to the undernourished, and often starving,

people of (at least) tropical Africa. In 1968 I wrote (Ucko & Dimbleby 1969, p. xx) that 'Domestication did not, of course, happen only once but has recurred time and time again in different parts of the world and at different times. Domestication as a process still continues.' *Foraging and farming* is an eloquent testament, 20 years later, both to the new approaches and to the new techniques which are now being applied to the study of the domestication by human beings of their environment. As such, this book is, and will remain for a long time, an exceptionally broad-ranging and thought-provoking account of a unique human endeavour.

P. J. Ucko
Southampton

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Contents

<i>Foreword</i>	P. J. Ucko	ix
<i>Preface</i>	David R. Harris & Gordon C. Hillman	xxxi
<i>Introduction</i>	David R. Harris & Gordon C. Hillman	1
References		7
THE EVOLUTION OF PLANT EXPLOITATION: CONCEPTS AND PROCESSES		
1	<i>An evolutionary continuum of people–plant interaction</i> David R. Harris	11
	Introduction	11
	Ecological and evolutionary approaches to understanding the emergence of agriculture	12
	The model: an evolutionary continuum of people–plant interaction	16
	References	24
2	<i>Darwinism and its role in the explanation of domestication</i> David Rindos	27
	Introduction	27
	The Darwinian perspective on plant domestication and agricultural evolution	28
	Fitness and relative, limited adaptation	35
	Natural selection and cultural change	38
	References	39
3	<i>Domestication and domiculture in northern Australia: a social perspective</i> A. K. Chase	42
	The domain of plants and people	43
	Domestication and domicultural action	47
	Aboriginal Australia, domestication, and agriculture	51
	References	53

4	<i>The domestication of environment</i> D. E. Yen	55
	The agronomy of Australian hunter-gatherers	57
	Social adjustments to foraging	62
	The domestication of environment	66
	Summary and conclusion	69
	Acknowledgements	72
	References	72
PLANT EXPLOITATION IN NON-AGRARIAN CONTEXTS: THE ETHNOGRAPHIC WITNESS		
5	<i>Wild-grass seed harvesting in the Sahara and Sub-Sahara of Africa</i> Jack R. Harlan	79
	Introduction	79
	Grass-seed productivity	80
	The desert zone	83
	Savanna	86
	Swamp lands	88
	Discussion	93
	References	95
6	<i>Australian Aboriginal seed grinding and its archaeological record: a case study from the Western Desert</i> Scott Cane	99
	Introduction	99
	Distribution	100
	Seasonal availability	103
	Seed processing	104
	Dietary importance of seed foods	110
	Seed-grinding implements	112
	Archaeological evidence for the use of seeds	114
	References	118
7	<i>Plant foods of the Gidjingali: ethnographic and archaeological perspectives from northern Australia on tuber and seed exploitation</i> Rhys Jones & Betty Meehan	120
	The ethnographic present	120
	Archaeological evidence	129
	Regional implications	130
	Acknowledgements	133
	References	133

8	<i>Plant usage and management in Southwest Australian Aboriginal societies</i> Sylvia J. Hallam	136
	Introduction	136
	Types of evidence	137
	Patch resources and sedentism	139
	Seasonal schedules of harvesting and occupance	141
	Labour investment, husbandry, and usage rights	142
	Settlement patterns and archaeological survey	143
	Antiquity and geomorphological impact	145
	Distribution and growth requirements of Australasian yams	146
	Conclusion	147
	Acknowledgements	147
	References	147
9	<i>Ethnoecological observations on wild and cultivated rice and yams in northeastern Thailand</i> Joyce C. White	152
	Environmental setting	153
	Wild rice	153
	Comparisons between wild and cultivated rice	154
	Wild yams	155
	Comparisons between wild and cultivated yams	156
	Conclusion	157
	References	158
10	<i>An example of intensive plant husbandry: the Kumeyaay of southern California</i> Florence C. Shipek	159
	Introduction	159
	Semi-domesticated grain	161
	Other plant-husbandry practices	162
	Maintenance of complex knowledge	165
	Conclusion	166
	References	167
11	<i>Plant-food processing: implications for dietary quality</i> Ann B. Stahl	171
	Introduction	171
	Techniques of plant-food processing	172
	Plant-food processing and subsistence change	184
	Acknowledgements	186
	Postscript on sources	186
	References	186

PLANT EXPLOITATION IN PRE-AGRARIAN CONTEXTS:
THE ARCHAEOLOGICAL EVIDENCE

12	<i>Plant exploitation at Grotta dell'Uzzo, Sicily: new evidence for the transition from Mesolithic to Neolithic subsistence in southern Europe</i>	Lorenzo Costantini	197
	Site location and environment		197
	The cave deposits and their chronology		198
	Recovery of plant remains		198
	Plant-food economy during the Mesolithic		199
	Emergence of Neolithic subsistence		201
	Conclusions		204
	References		204
13	<i>Late Palaeolithic plant foods from Wadi Kubbaniya in Upper Egypt: dietary diversity, infant weaning, and seasonality in a riverine environment</i>	Gordon C. Hillman	207
	Source and nature of the remains		207
	Dietary diversity and 'missing foods'		217
	Wild nut-grass (<i>Cyperus rotundus</i>) as a possible staple source of carbohydrate		224
	Wild-tuber management? The possibility of 'incidental propagation'		226
	Role of the Kubbaniya grinders		227
	Faecal remains and evidence of infant weaning in the Palaeolithic		228
	Seasonality		230
	Conclusions		232
	Acknowledgements		233
	References		233
14	<i>Plant-food economy during the Epipalaeolithic period at Tell Abu Hureyra, Syria: dietary diversity, seasonality, and modes of exploitation</i>	Gordon C. Hillman, Susan M. Colledge, & David R. Harris	240
	Introduction		240
	Were the Epipalaeolithic populations already cultivating major food plants?		241
	How diverse was the range of plant foods exploited during the Epipalaeolithic?		258
	At what seasons was the site occupied during the Epipalaeolithic?		261
	Conclusion		264
	Postscript		265
	Acknowledgements		265

Notes	266
References	266
15 <i>Mesolithic exploitation of wild plants in Sri Lanka: archaeobotanical study at the cave site of Beli-Lena</i> M. D. Kajale	269
Introduction	269
Descriptions of the four types of plant-food remains from Beli-Lena	271
Role of these wild-plant foods in local subsistence	276
Chronology of the remains	277
Previous records of the same plant foods	278
Phytogeographical and taxonomic affinities	278
Conclusion	280
Acknowledgements	280
References	281
16 <i>New evidence on plant exploitation and environment during the Hoabinhian (Late Stone Age) from Ban Kao Caves, Thailand</i> Kosum Pyramarn	282
Introduction	282
The plant types identified and their possible prehistoric uses	283
Conclusions	289
Acknowledgements	290
References	290
17 <i>The taming of the rain forests: a model for Late Pleistocene forest exploitation in New Guinea</i> Les Groube	292
Human colonization of the Late Pleistocene forest environment	292
Evidence for Late Pleistocene forest exploitation	294
Interpretation of Late Pleistocene forest exploitation	298
From forest foraging to gardening: an evolutionary model	301
References	302
18 <i>Seed gathering in inland Australia: current evidence from seed-grinders on the antiquity of the ethnohistorical pattern of exploitation</i> M. A. Smith	305
Recognizing the use of seed foods in the archaeological record	305
The chronological distribution of seed-grinding implements	308
Economic and technological precursors	311

Initial colonization of the arid zone	312
Explanations for an intensification of seed use	313
Acknowledgements	315
References	315
19 <i>Adaptation of prehistoric hunter-gatherers to the high Andes: the changing role of plant resources</i> Deborah M. Pearsall	318
Introduction	318
The charred plant remains	320
The role of plant resources in adaptation to the <i>puna</i>	324
Domestication of weedy plants and camelids: a model for co-evolution of Andean herding and agriculture	327
Conclusions	330
Acknowledgements	331
References	331
AGRARIAN PLANT EXPLOITATION: THE DOMESTICATION AND DIFFUSION OF CROPS AND CROP ASSEMBLAGES	
20 <i>The tropical African cereals</i> Jack R. Harlan	335
Sorghum	335
Pearl millet	339
Finger millet	340
African rice	341
Teff	341
<i>Digitaria</i> spp.	341
<i>Brachiaria deflexa</i>	342
Abyssinian oat	342
Conclusion	342
References	343
21 <i>Factors responsible for the ennoblement of African yams: inferences from experiments in yam domestication</i> V. E. Chikwendu & C. E. A. Okczic	344
Objectives	344
Research methods	345
Data collected	348
Morphological and ecological changes observed	349
Factors responsible for the observed changes	354
Conclusion	355
References	356

22	<i>Domestication of the Southwest Asian Neolithic crop assemblage of cereals, pulses, and flax: the evidence from the living plants</i> Daniel Zohary	358
	Introduction	358
	Identification of the wild progenitors	359
	Distribution areas and the place of domestication	367
	Preadaptation for cultivation	369
	Patterns of domestication: solitary versus multiple events	369
	Postscript	371
	Appendix: note on botanical names of crop plants	371
	References	372
23	<i>Origin and domestication of the Southwest Asian grain legumes</i> Gideon Ladizinsky	374
	Food legumes	374
	'Forage' legumes	381
	The process of pulse domestication	381
	Geographical pattern of pulse domestication	385
	Broad-spectrum domestication of legumes	387
	References	388
24	<i>Cryptic anatomical characters as evidence of early cultivation in the grain legumes (pulses)</i> Ann Butler	390
	Introduction	390
	Recognition of dehiscency in pulse crops	390
	Seed dormancy and the nature of the legume testa	391
	The present study	395
	Discussion of results	395
	Acknowledgements	405
	References	405
25	<i>Domestication and the spread of the cultivated rices</i> T. T. Chang	408
	Evolutionary pathway of the two rice cultigens	408
	Beginning of rice cultivation	409
	Domestication versus cultivation	410
	Antiquity of rice cultivation in Asia	410
	Ecogeographic diversification	412
	Dispersal	412
	Contrasts between the Asian and African cultigens	415
	Areas for future endeavour	415
	References	416

26	<i>Crops of the Pacific: new evidence from the chemical analysis of organic residues in pottery</i>	H. Edward Hill & John Evans	418
	Chemical analysis of organic residues		418
	Identification of Pacific food plants from the chemical-spectra 'characterization'		421
	Analysis of archaeological samples		421
	Summary and conclusions		424
	Acknowledgements		425
	References		425
27	<i>Cytological and genetical evidence on the domestication and diffusion of crops within the Americas</i>	Barbara Pickersgill	426
	Phytogeographical background		427
	Nature and causes of differentiation in disjunct populations		428
	Tomato		429
	Maize		430
	Chili peppers		431
	Grain chenopods		433
	Cotton		435
	Conclusions		436
	References		437
28	<i>Maize: domestication, racial evolution, and spread</i>	Garrison Wilkes	440
	The selection pressures of domestication		440
	Two rules in crop domestication		441
	Artificial selection ('anthro-selection') in traditional agriculture		442
	Selection pressures in the domestication of maize		443
	Geographical centre for the origin of maize		445
	Archaeological evidence of maize from Tehuacan		446
	The wild relatives of maize		447
	Theories of the origin of maize		449
	Continued hybridization with teosinte and the recent evolution of maize		451
	Maize: a human achievement in altering a plant		452
	References		453
29	<i>Andean maize: its origins and domestication</i>	Duccio Bonavia & Alexander Grobman	456
	Archaeological history of maize in the Andean region		456
	Relationships between Mesoamerican and Andean maize		459
	Archaeological evidence of other crops in the Peruvian highland and coastal regions		464

Additional evidence of maize from Chile and Argentina	465
Conclusions	466
Note	467
References	467
30 <i>Domestication of Cucurbitaceae: Cucurbita and Lagenaria</i> Charles B. Heiser, Jr.	471
The squashes: <i>Cucurbita</i> spp.	471
The bottle gourd: <i>Lagenaria siceraria</i>	475
Conclusion	478
Acknowledgements	478
References	478
31 <i>The domestication of roots and tubers in the American tropics</i> J. G. Hawkes	481
Introduction	481
Origins of root and tuber domestication	481
Climatic and phytogeographical crop groups	482
Individual crop origins	485
Conclusions	498
Acknowledgements	499
References	499
32 <i>A chemical–ecological model of root and tuber domestication in the Andes</i> Timothy Johns	504
Human chemical ecology	504
Limiting the toxicity of crop plants	505
Andean root and tuber crops	505
Biological and cultural aspects of chemical selection	507
Altiplano agriculturalists: limiting plant toxicity	508
<i>Solanum x ajanhuiri</i> domestication complex	509
Taste perception and chemical selection	511
A historical perspective on potato domestication	512
Detoxification techniques	513
The detoxification function of geophagy	513
Geophagy and domestication	514
An overview of chemical determinants of plant domestication	515
References	517
 AGRARIAN PLANT EXPLOITATION: THE EVOLUTION OF AGRICULTURAL SYSTEMS	
33 <i>From foraging to food production in northeastern Venezuela and the Caribbean</i> Mario Sanoja	523

	Social conditions for controlled food production	524
	The development of early village communities in northeastern Venezuela	526
	Hunter-gatherer communities of the Greater Antilles and the processing of plant foods	531
	The development of food production in the western and eastern Caribbean	534
	References	535
34	<i>Non-affluent foragers: resource availability, seasonal shortages, and the emergence of agriculture in Panamanian tropical forests</i> Dolores R. Piperno	538
	Introduction	538
	Wild resource availability in tropical forests	540
	Early plant domestication in Panama	544
	Early land usage and the 'cost' of early food production	548
	The implications of wild resource availability in regenerating plots and other regrowth vegetation	549
	Conclusions	549
	Acknowledgements	550
	References	551
35	<i>Early plant cultivation in the Eastern Woodlands of North America</i> Patty Jo Watson	555
	Introduction	555
	Eastern Woodlands prehistory: a brief summary	556
	Early plant cultivation in the Eastern Woodlands	557
	Aboriginal subsistence in the eastern forests	561
	Interpretations of the evidence and the processes	563
	Acknowledgements	565
	References	565
36	<i>Agricultural intensification and ridged-field cultivation in the prehistoric upper Midwest of North America</i> James P. Gallagher	572
	Introduction	572
	The development of superior plant varieties	573
	Site location	575
	Ridged fields	575
	Field burning	580
	Summary	580
	Acknowledgements	580
	References	581

37	<i>The spread of agriculture in western Europe: Indo-European and (non-)pre-Indo-European linguistic evidence</i> T. L. Markey	585
	Introduction	585
	The case of barley	589
	Rye and oats	593
	The plough (and the pig)	596
	Indo-Europeans in western Europe: the evidence of the apple	599
	Conclusion	601
	References	603
38	<i>Agricultural evolution north of the Black Sea from the Neolithic to the Iron Age</i> Zoya V. Yanushevich	607
	The Neolithic	607
	The Eneolithic	611
	Bronze Age	613
	Iron Age	613
	Summary of records for the steppe and wooded-steppe zones	613
	The Crimea	615
	General conclusions	617
	References	619
39	<i>The transition from foraging to farming in Southwest Asia: present problems and future directions</i> A. M. T. Moore	620
	Significance of the development of agriculture	620
	The environmental background to the development of agriculture	622
	The location of sites	623
	Interpretations	625
	Fresh insights and future directions	627
	References	629
40	<i>Early farming communities in the Jordan Valley</i> Ofer Bar-Yosef & Mordechai E. Kislev	632
	Changes preceding the Neolithic	632
	The early Neolithic (c. 10 500–9300 bp) in the Jordan Valley	634
	Botanical rationale for barley being the first crop in the Jordan Valley	636
	Conclusions	640
	References	640
41	<i>Prehistoric agriculture in China</i> An Zhimin	643
	The Neolithic cultural sequence	643
	The development of agriculture	645
	Crops	645
	Agricultural implements	647

Domestic animals	648
Conclusion	649
References	649
42 <i>Coastal adaptation, sedentism, and domestication: a model for socio-economic intensification in prehistoric Southeast Asia</i> Charles Higham & Bernard Maloney	650
Introduction	650
The site and environment of Khok Phanom Di: faunal and pollen evidence	656
Coastal adaptation and sedentism	661
Intensification	664
Conclusion	665
Acknowledgements	665
References	666
43 <i>The transition from stone to steel in the prehistoric swidden agricultural technology of the Kantu' of Kalimantan, Indonesia</i> Michael R. Dove	667
Introduction	667
Iron among the contemporary Kantu'	667
Stone among the Kantu'	669
The evolution from stone to iron	670
Supporting evidence	673
Conclusion	675
Notes	676
References	677
44 <i>The origins and development of New Guinea agriculture</i> Jack Golson	678
Agricultural origins	678
Agricultural development	683
Concluding remarks	685
Acknowledgements	685
References	685
45 <i>Gardens in the south: diversity and change in prehistoric Maaori agriculture</i> Susan Bulmer	688
Introduction	688
Reconstructing the prehistoric landscape	689
Archaeological evidence of Maaori garden systems	692
Agricultural diversity and change in Aotearoa	699
References	702
<i>Index</i>	706

Preface

In today's world plants provide the 'daily bread' of over five billion human beings. With very few exceptions, human societies have relied more heavily on plant than on animal foods for their sustenance, and the history of human intervention in the plant world no doubt reaches back uninterruptedly to our earliest hominid ancestors. During the many millennia of interaction between people and plants, humans have learnt to exploit plants in diverse ways for myriad purposes, especially for food. In so doing they have developed ingenious methods of processing plant parts that would otherwise remain inedible, and have thus extended the range of species which could be exploited.

Looking back over the thousands of years of interaction between people and plants, we can recognize thresholds when new methods of exploitation came to be applied, and the often symbiotic relationships established between plants and people underwent major changes. Among such thresholds we can include the earliest use of pounding stones to macerate fibrous stems, roots, and tubers, and to crack nuts; the controlled burning of vegetation to enhance the yields of edible plant products (or, indirectly, of game animals); the elaboration of methods of harvesting and storing seeds; cooking by boiling plant foods in pottery, shell, or wooden vessels; fermentation; the detoxification of bitter and poisonous roots, tubers, and seeds by leaching; and, of course, cultivation. All these technical innovations could be, and no doubt were, applied to wild plants, but at some time in the evolution of the increasingly close relationship between people and plants, human control over the reproductive systems of particular species became so direct that those plants lost their ability to survive in the wild without human assistance. Thus domestication (in the orthodox sense) came about, and, in combination with cultivation, led to agriculture (see Chapter 1).

There has long been a tendency to regard 'the origins of agriculture' as an overwhelmingly important 'stage' or 'event' in the development of human society. In terms of its consequences for humankind it undoubtedly was; but we prefer to see it as part – though certainly a very significant part – of the long-term evolution of plant exploitation. Our aim in this book is therefore to bring together the results of recent research on plant domestication and early agriculture within an evolutionary framework which emphasizes the continuities as well as the thresholds in the intensifying relationship over time of people to plants.

The origins of the book go back to 1983 when one of us (DRH) first became involved in helping Peter Ucko to plan the academic content of what was to become, in 1986, the World Archaeological Congress held at Southampton. It was soon agreed that the broad international forum of the

Congress would provide a unique opportunity to organize a symposium on plant domestication and early agriculture viewed from a world-wide perspective. It had been apparent for some time that a re-examination of that long-debated topic was overdue, because so much new evidence had become available since it was last reviewed at an international conference. So, we agreed to take on the task of organizing the symposium, and, if it proved academically successful, of publishing the result. Thus began a five-year commitment to what became a gargantuan, often daunting, but always exciting task which led eventually to the appearance of this book.

From the first, we took the view that the symposium would depend for its success on the participation of a core of botanists and archaeologists who had made major contributions to the subject. We also hoped to attract many less established scholars who had new research results to report. Among those who were on our original list of 'invitees', and who did in fact participate in the symposium at Southampton, were Jack Golson, Jack Harlan, Jack Hawkes, Charles Heiser, Timothy Johns, Rhys Jones, Mukund Kajale, Barbara Pickersgill, David Rindos, Garrison Wilkes, and Daniel Zohary. Many other archaeologists, botanists, and anthropologists also contributed papers to the symposium and participated in the discussion; and we were fortunate in being able to persuade several scholars who did not come to Southampton, but who we knew could make very valuable contributions to the eventual book, to set aside time to write chapters specifically for it: Ofer Bar-Yosef and Mordechai Kislev, Lorenzo Costantini, Gideon Ladizinsky, Florence Shippek, Patty Jo Watson, Joyce White, and Douglas Yen. Five contributors to the book were prevented by lack of funds and other reasons from attending the symposium in Southampton although they had written papers for pre-Congress circulation: Te-Tzu Chang, Michael Dove, Charles Higham, Kosum Pyramarn, and Zoya Yanushevich; three – Alexander Grobman, Bernard Maloney, and Betty Mechan – became co-authors of papers which were initially presented at Southampton; and one – Les Groube – made a spontaneous verbal contribution to the symposium which formed the basis of what became his chapter in the book. We are also pleased to be able to include a second chapter by Jack Harlan – on the tropical African cereals – which is an edited version of a recording of the seminar he gave at the Congress in the session on 'The Neolithic of Africa'.

Although it was never our intention to try to include in the symposium contributions dealing with all the main geographical regions of the world, we did, because the Congress proved to be a uniquely international gathering, benefit from the active participation of representatives from an extraordinarily wide range of national and cultural backgrounds. This has, in turn, enlarged the geographical and chronological scope of the book, which now includes data from most regions of the world where research relevant to the evolution of plant exploitation is being carried out. We had hoped, in fact, to include four further contributions which would have helped to fill what may now be perceived as 'gaps' in the scope of the book – dealing with early agriculture in India, Pakistan, Northeast Asia, and Southeast Europe –

but unfortunately this proved impossible to achieve before the final publication deadline.

We look back on the symposium itself as in some ways the most improbable and yet productive academic meeting we have ever experienced. From the start we insisted that the two days allotted to it would be devoted only to discussion, based on the unedited papers that had already been circulated to all registered participants. All but the last-minute papers were included in the pre-Congress publication entitled 'Recent Advances in the Understanding of Plant Domestication and Early Agriculture' which provided the substantive background to the symposium. In the event, everyone's natural inclination to at least summarize their paper was diverted into a collective commitment to vigorous discussion. This was due in no small measure to the enthusiasm with which all those whom we had asked to join us in the task of 'creative chairmanship' and to act as discussants at the end of each session, took up their successive tasks: Peter Bellwood, Noel Broadbent, Athol Chase, Ian Glover, Jack Golson, Jack Harlan, Jack Hawkes, Charles Heiser, Rhys Jones, and Barbara Pickersgill. We thank them all again most warmly for contributing so much to the success of the symposium, and thereby to the eventual appearance of this book. At the end of the symposium we were elated *and* exhausted, but very satisfied that so many botanical, archaeological, and anthropological colleagues from all the inhabited continents had met, mixed convivially, and sustained two days of intensive academic debate at a frontier of knowledge.

So, by September 1986, this book, conceived in 1983, had attained embryonic form. Since then it has undergone an 18-month period of gestation during which all the contributors have uncomplainingly accepted the unavoidable delays and sometimes radical revisions involved in the editorial process. We thank them all, and Peter Ucko, for joining – and bearing – with us in the travail that preceded its birth, an event which would never have happened had we not had the unflinching help of two successive, efficient, and unflappable departmental secretaries: Sally Davis and Heather Binney. If this book awakens – and enlarges – interest among people of many nations in the obscure history of how humankind made the fateful transition from foraging to farming, the effort of all involved in producing it will be well rewarded.

David R. Harris
Gordon C. Hillman
Institute of Archaeology
University College London
1 April 1988

Radiocarbon dates

Throughout the text, bp, bc and ad refer to uncalibrated radiocarbon dates. BC and AD are used to indicate calibrated radiocarbon dates and calendric dates.

Note

The final date for revision by authors of their contributions to this book was 30 June 1988.

Introduction

DAVID R. HARRIS and GORDON C. HILLMAN

Twenty years have passed since the first major international seminar to be held on plant and animal domestication took place at the Institute of Archaeology in London. That remarkable meeting led to the publication of *The domestication and exploitation of plants and animals* (Ucko & Dimbleby 1969), a seminal volume which both reviewed the then state of knowledge of the subject and anticipated many of the research topics which were to be actively pursued by anthropologists, archaeologists, biologists, and other scholars in the next two decades. Although what Flannery referred to in 1973 (p. 271) as 'the bandwaggon of agricultural-origins research' now commands proportionately less attention in archaeology than it did in the 1960s, much new evidence on domestication and early agriculture has been recovered since then, not only in such relatively well-studied regions as Southwest Asia and Mesoamerica but also in many other parts of the world. At the same time there has been, since 1969, a major new development in the subject, focusing on the investigation of hunter-gatherer subsistence, as a topic in its own right and for its relevance to understanding 'the origins of agriculture'. Several new scientific techniques for probing the prehistory of human subsistence have also become available, particularly new bioarchaeological methods of recovering, identifying, and analysing plant and animal remains from archaeological sites, and, most recently, the revolutionary technique of radiocarbon dating by accelerator mass spectrometry (Gowlett & Hedges 1986, Harris 1987) which allows extremely small (<5 mg) samples, such as individual seeds, to be dated directly.

As the subject broadens in its geographical, thematic, and technical scope there is a danger of it becoming so diffuse – with individual researchers scattered across the globe preoccupied with their own particular projects – that the world-wide comparative perspective (which was achieved at the seminar in 1968) is lost, and the wider significance of new evidence is not realized. The aim of this book, therefore, after an interval of two decades, is to re-examine the theme of domestication and early agriculture on a global scale, to make new evidence generally available, and to assess our present understanding of how humans came to make the fundamental shift from dependence on wild foods to dependence on domesticated plants and animals, a dependence which today sustains almost the entire human population.

In 1969 it was possible within the confines of one – admittedly large – volume to encompass plant *and* animal domestication, although even then

several important areas of study, for example animal domestication in the Americas, were not represented. To do so now would be impracticable, however methodologically desirable, because of the great growth in knowledge of both plant and animal domestication. We therefore make no apology for limiting the theme of this book to plant exploitation – and at the same time allowing animals a mention whenever they are integral to the topic of a chapter (e.g. in the contributions of An, Golson, Groube, Higham & Maloney, Kajale, Ladizinsky, Markey, Moore, and Pearsall). We also take the view that, overall, the emergence of agriculture is more closely linked to the pre-agrarian exploitation and domestication of plants than of animals, notwithstanding the fact that in certain regions of the world, notably Southwest Asia and the Central Andes, plants and herd animals may have interacted synergistically under human exploitation in the evolution of local agricultural systems. Cultivated and domesticated crop plants are, after all, in a very literal sense the essential biotic elements of production in all systems of agriculture (apart from the people themselves), the only possible exception being the marginally 'agricultural' system of nomadic pastoralism.

The cardinal theme of this book, then, is the evolution of plant exploitation from 'foraging' to 'farming', which subsumes within it such ill-defined but crucial concepts as food procurement, food production, cultivation, domestication, and, of course, agriculture. The connotations and interconnections of these terms are examined in the first chapter, which serves in some ways as an extended introduction to the general theme of the book: that of interaction between people and plants as a continuum, and also a gradient of increasing intensity, through time. We thus regard human exploitation of plant resources as a global evolutionary process which, in different regions at varying times in the past, incorporated the beginnings of cultivation and crop domestication. This approach reduces but does not deny the conceptual dichotomy between 'hunter-gatherers' and 'agriculturalists' by treating the development of *all* techniques of plant exploitation as an integral part of the evolutionary ecology of *Homo sapiens*.

One of our main objectives in organizing the international symposium out of which this book has grown, was to bring together biologists who have made major contributions to the study of plant domestication and archaeologists whose research has focused explicitly on the beginnings and early development of agriculture. We did not set out to achieve world-wide geographical or comprehensive chronological coverage, although in the end we have been able to include contributions dealing with a very wide range of regions and time periods. Most contributors report newly discovered evidence in their chapters, and in some cases they have also discussed new applications of scientific techniques (e.g. Pearsall's and Piperno's discussions of phytolith analysis, Pickersgill's of isozyme analysis, Butler's of anatomical micromorphology, and Hill's & Evans' of infra-red spectroscopy applied to the analysis of organic residues in pottery). These demonstrations of the relevance of such techniques add a further valuable dimension to the book, but we should emphasize that it has not been part of our purpose comprehen-

sively to review the range of new techniques that are beginning to be applied to the study of past plant exploitation. That is a fast-developing field which deserves a book to itself.

Our aim throughout this volume is to treat the prehistory and history of plant exploitation as a continuous evolutionary process. The division of the book into separate parts on agrarian, and non- and pre-agrarian, plant exploitation may appear to contradict this aim, but we believe the contents of the individual chapters belie that objection. In fact, in some cases our decision to include a particular contribution in one part rather than another borders on the arbitrary. Although an implicitly chronological arrangement – from pre- and non-agrarian subsistence through cultivation and domestication to agriculture – could have been adopted (indeed, that was our original intention), we finally decided that the book should start with four theoretical contributions which discuss, from different perspectives, the concepts we use and the processes we examine when studying the evolution of plant exploitation.

The four chapters in the first part introduce two other distinctive aspects of the book: the diversity of intellectual perspectives and scholarly skills which are represented in it, and the major contribution made to it by data on 'hunter-gatherer' subsistence, especially from recent studies in Australia (see particularly the chapters by Cane, Chase, Hallam, Jones & Meehan, Smith, and Yen). In terms of their academic affiliation, the contributors to the book range from the biological sciences to archaeology, anthropology, history, and linguistics. Biological and archaeological-ethnographic studies predominate, but social-anthropological, historical, and linguistic data also constitute an important part of several chapters (e.g. those by Chase, Dove, Hallam, Harlan, Markey, and Shipek).

Within the primarily biological contributions, evidence and insights from a wide range of specialisms are presented. All the biological contributors share an ecological and evolutionary approach, within which they bring their particular skills to bear on the subject, e.g. Grobman's, Hawkes', Heiser's, Pickersgill's, and Wilkes' discussion of the taxonomic, genetic, and cytological evidence for the domestication and diffusion of maize and other crops of the American tropics; Chikwendu's & Okezie's experimental study of yam domestication; Johns', and Hill's & Evans', biochemical approaches to, respectively, Andean root and tuber crops, and Pacific Island crops; Butler's application of anatomical micromorphology to the Southwest Asian grain legumes; Maloney's palynological investigation of the local environment of a key archaeological site in Thailand; Stahl's discussion of the dietary implications of plant-food processing; and the ecological-genetic reviews of the domestication of the major grain crops of Southwest Asia by Zohary, Kislev, and Ladizinsky, of the tropical African cereals by Harlan, and of rice by Chang.

The specifically archaeobotanical contributions are a distinctive feature of the book, in that they focus on the analysis and interpretation of assemblages of plant remains recovered from particular archaeological sites. Like the

other biological contributors, the authors of these chapters approach their data from an ecological–evolutionary perspective. Some of them are concerned with single pre-(or non-)agrarian sites (Costantini, Hillman, Hillman *et al.*, Kajale, Pyramarn), others with regionally defined clusters of sites which either encompass the domestication process itself and/or early post-domestication agriculture (Pearsall, Piperno, Watson, Yanushevich).

Another group of contributors approaches the subject from a more exclusively archaeological point of view by focusing attention on lithic and ceramic artefacts used in processing plant foods and for other subsistence-related activities (Cane, Groube, Sanoja, Smith); on regional subsistence–settlement patterns and chronological sequences (An, Bar-Yosef, Bonavia, Higham, Moore, Sanjoa); and on field and stratigraphic evidence for agricultural (and ‘horticultural’: cf. Harris in Ch. 1) systems (Bulmer, Gallagher, Golson); though these authors, too, share the ecological orientation which characterizes the entire book (and which is made particularly explicit in the three chapters written jointly by archaeologists and botanists: Bar-Yosef & Kislev, Bonavia & Grobman, Higham & Maloney).

Finally, we emphasize again the central importance of ethnographic, or what we might more aptly call ‘ethnoecological’, data in the book as a whole. It forms an important part of most of the biological and archaeological contributions, and it is an essential ingredient in many of those that are concerned with agrarian, as well as with all those that focus on non- and pre-agrarian, plant exploitation (perhaps most conspicuously in the chapters by Cane, Dove, Hallam, Harlan (Ch. 5), Jones & Meehan, Shipek, White, and Yen).

Our decision to divide the book into five parts – a largely theoretical first one followed by two parts each on non- and pre-agrarian, and agrarian, plant exploitation – has already been referred to, but it does require some further justification of the individual parts and of the sequence of chapters within them. In Chapter 1, discussion of the concepts of cultivation, domestication, and agriculture provides a unifying framework for the more specialized and ‘factual’ contributions which follow. In Chapters 1–4, a clear distinction emerges between the use of the term domestication to denote (crop) plants that have been genetically and/or phenotypically modified by human intervention in their reproductive systems (the orthodox connotation), and the enlargement of the term to embrace the concept of the domesticated environment. This latter connotation is developed here on a magisterial scale by Yen, on a more local scale by Chase who, with Hynes (1982), introduced the neologism ‘domiculture’, and it is also implicit in Rindos’ division (1984 and here) of the concept into ‘incidental’, ‘specialized’, and ‘agricultural’ domestication.

Having explored the conceptual framework of the subject as well as initiating discussion of the processes involved in plant domestication, we then introduce in the second part (Chs 5–11) an array of ethnographic data on plant exploitation by ‘hunter–gatherers’ which demonstrates the diversity and complexity of the techniques used, many of which are shown closely to

resemble agronomic practices of agriculturalists (cf., in the first part, Yen's use of the phrase 'the agronomy of hunter-gatherers', and Harris' inclusion of such activities as sowing, transplanting, tilling, irrigation, and drainage in pre-domestication wild plant-food production). The ethnographic data in the second part relate mainly to the non-agricultural exploitation of wild grasses and other seed-yielding plants, and such tuber-bearing taxa as yams, examples being drawn from Africa, Asia, Australia, and North America. It ends with a comprehensive discussion by Stahl of plant-food processing techniques and their nutritional implications.

In the third part (Chs 12–19) we turn to the archaeological evidence of pre-agrarian plant exploitation, and present the results of eight recent archaeobotanical studies which range geographically from Mediterranean Europe and North Africa through Southwest, South, and Southeast Asia to New Guinea, Australia, and South America. Collectively, these chapters represent a major contribution to the investigation of pre-agrarian plant use, diet, and seasonality, and the authors of three of them (Costantini, Groube, and Pearsall) also develop locally applicable models for transitions from 'hunter-gatherer' to 'agricultural' or 'horticultural' subsistence.

In the fourth and fifth parts (Chs 20–45) we cross the threshold of crop domestication (in the orthodox sense of the term) and present a wide range of evidence on the evolution of crops and of agriculture. The diversity of contributions to these sections of the book is so great that their separation into two parts, and the sequence of the chapters within each part, is somewhat arbitrary. But we believe that the division we have adopted between, on the one hand, the domestication and diffusion of crops and crop assemblages (fourth part, Chs 20–32), and, on the other hand, the evolution of agricultural systems (fifth part, Chs 33–45), is both logical and useful, although we readily admit that not all the contributions to the fifth part are concerned with agricultural *systems* as such. In arranging the individual chapters in the fourth and fifth parts we have adopted a sequence that, as far as possible, groups together contributions relating to similar crops, geographical regions, and continents.

A book as large and diverse as this one defies editorial distillation of a comprehensive series of general conclusions. Instead we end this Introduction with brief comments on three aspects of our subject that appear to us to have general relevance to future investigations. The first is the question of how we should attempt to identify the areas of earliest cultivation and domestication of particular crops. The conventional ('Vavilovian') approach has been to assume that the present-day distributions of the (known or assumed) progenitors, or the nearest modern relatives and/or the 'primitive' varieties, of the crops under investigation are likely to represent the 'homelands' of those crops (Harris in press). This assumption has often been challenged on the grounds that it ignores the possibility of climatically induced or other environmental changes having so altered the distribution of plant communities, in the interval since the crops were first cultivated and domesticated, that the present-day distribution patterns cannot be used as a

guide to the areas where the progenitors were first taken into cultivation. How much weight should be given to this criticism will depend on how precisely the 'homeland' is being defined, and how much is securely known about environmental change – or lack of it – in the area. All we wish to do is to stress the importance of developing new and more refined methods of reconstructing past distribution patterns of the relevant plant communities, not only by means of pollen analysis but also by developing and applying the less proven techniques of phytolith and wood-charcoal analysis. This approach to vegetation change needs also to be combined with detailed ecological studies of the plant communities in which the progenitors, or their nearest modern relatives, occur today, so that the habitats in which the progenitors formerly occurred can be characterized. The principal value of studying the distribution patterns of present-day plant communities therefore lies in what they can tell us about the habitat preferences of the progenitors, and not in what we may uncertainly infer about where those communities occurred in the past.

Our second concluding comment relates to the long-debated question of how particular taxa came to be selected (whether deliberately or not) as cultigens. This is a complex question, which invites contrasted types of 'explanation', such as 'co-evolution' versus 'cultural preference'. Our present purpose is only to point to the potential value of detailed comparative studies of the basic morphological and ecological characteristics of groups of closely related plants in a given type of habitat to identify potential cultigens according to stated criteria of selection. Kislev's comparison (Ch. 40) of 23 species of large-seeded grasses that grow in the Jordan Valley well illustrates the value of this approach, which could profitably be applied to many groups of plants from which the selection of cultigens may appear to have been relatively arbitrary.

Our third conclusion relates directly to one of the central themes of the book, namely the process of domestication. Here we use the term in its orthodox sense, already referred to, to mean human intervention in the reproductive system of the plant, resulting in genetic and/or phenotypic modification. We suggest that three distinct, though not mutually exclusive, pathways to the state of domestication are represented in this book.

- (a) The first pathway selects for very rapid genotypic change involving the loss of the ability of the plant to survive in the wild. This pathway is represented by Ladizinsky's discussion (Ch. 23) of the (according to his model, pre-cultivation) domestication of the Southwest Asian grain legumes, in which he postulates the mechanisms involved *and* estimates the possible rate of the domestication process. It is also represented by Zohary's discussion (Ch. 22) of the (post-cultivation) domestication of the Southwest Asian cereals and pulses, although he does not attempt to specify the mechanisms involved nor speculate about the rates of domestication. Investigation of domestication rates is potentially most important for our understanding of the beginnings of agriculture, and

can be approached experimentally, as work by Hillman and Davies (in press) has recently shown.

- (b) The second pathway to domestication selects for gradual genotypic change, and again involves (eventual) loss of the ability of the plant to survive in the wild. It is a process of slow incremental ‘ennoblement’ dependent on sustained ‘anthro-selection’ (to use Wilkes’ term) which has often continued to the present in areas of ‘primitive’ agriculture. This pathway is exemplified by Wilkes’ discussion of the evolution of maize (Ch. 28).
- (c) The third pathway contrasts with the other two in not apparently involving any directional genotypic change between the wild progenitor and the domesticated form. Although the changes in the appearance of plants may be dramatic, they involve only ‘plastic’ phenotypic changes occurring within the limits of phenotypic plasticity determined by the unaltered genotype. Such changes can be very rapid and they are reversible, in the short term at least. This pathway is exemplified by Chikwendu’s and Okezie’s experimental domestication of West African yams (*Dioscorea rotundata*) (Ch. 21), and it may have occurred quite widely among root and tuber crops.

As already stated, we do not suggest that these three pathways are mutually exclusive – indeed, most plant domestication is likely to have combined genotypic changes with conspicuous (but still partially reversible) plastic changes in the phenotype, as Heiser’s discussion of the *Cucurbita* squashes (Ch. 30) and Hawkes’ of the potato (Ch. 31) imply – but the three pathways do appear to represent distinctly different routes from wild progenitor to cultigen, and study of them is therefore fundamental to understanding the evolution of plant exploitation.

It is that understanding which we hope this book will advance, not by debating hypothetical ‘explanations’ of the *origins* of agriculture but by focusing on the *processes* and *effects* – biological, ecological, demographic, economic, and social – of the exploitation of plants by people. We offer the book as a conspectus of much of what is presently known about *how* humans have harvested, planted, processed, and altered plants over the millennia, and in so doing have ‘domesticated’ themselves.

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THE EVOLUTION OF
PLANT EXPLOITATION:
CONCEPTS AND
PROCESSES

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1 *An evolutionary continuum of people–plant interaction*

DAVID R. HARRIS

Introduction

Philosophical speculation about how plants and animals were domesticated and about how agriculture arose can be traced in the Western intellectual tradition at least back to Classical times – for example in Lucretius' discussion of animal domestication (Glacken 1967, pp. 139–40) – but substantive enquiry into the beginnings of agriculture and the history of domesticated plants and animals is little more than a century old. Indeed, field and laboratory investigations designed specifically to throw light on the emergence of agriculture, conducted by archaeologists and biologists, have been underway for little more than four decades. During that brief period an impressive array of bioarchaeological evidence has been recovered from early agrarian sites in many tropical and temperate regions of the world, and ethnographic and historical research has made a major contribution to the interpretation of that evidence. But the exciting and often controversial debates that have accompanied attempts to understand 'the origins of agriculture' have often been bedevilled by confusion over the meanings attributed to such terms as agriculture, cultivation, domestication, and food production.

To point this out is not to engage in semantic quibbling, because the meanings attributed to such general concepts can and do directly affect research design and the interpretation of evidence. The purpose of this chapter is therefore to present – against the background of a review of earlier uses of such concepts – a classificatory model which arranges them along a continuum of people–plant interaction. It is hoped that this will help to clarify our thinking about the processes involved in the emergence of agriculture, and also that it will provide a useful prelude to the other contributions to this part of the book. The concept of a continuum of interaction, developed in this chapter, need not of course be restricted to *plants* and people; it could productively be extended to animal–people interaction. Its limitation here to plants is a function of the overall theme of the book, and in part also a reflection of the primacy of plants in the structure and function of agricultural systems (agroecosystems), whether or not they incorporate domesticated animals.

The intellectual assumptions that underlie the model presented here are

ecological and evolutionary: ecological in that the analytical target is *interaction* between people and plants, evolutionary in that the *results* of the processes involved in domestication and the emergence of agriculture – i.e. the crops, domestic animals, and agricultural practices that we seek to trace in the archaeological record – are assumed to be the products of selection working on both biological and cultural variation. It is therefore evolutionary in a Darwinian sense (cf. Rindos Ch. 2, this volume), but not in the progressive sense of the cultural-evolutionary school of mid-twentieth century American anthropology exemplified by Sahlin & Service (1960). Before discussing the model itself (in the last section of this chapter), it is therefore necessary to emphasize that it is not unidirectional, and it certainly does not imply that, given sufficient 'time', human societies would inevitably progress from one level of interaction with plants (or animals) to the next. The levels of interaction specified in the model (Fig. 1.1) are not to be regarded as pre-ordained steps on a ladder of increasingly 'advanced' stages of general societal development; nor is it implied that transitions from one level to another, e.g. from cultivation to domestication, are necessarily irreversible. However, the model *is* progressive in one specific sense, in that the proposed continuum is presented as a gradient of increasing input of human energy per unit area of exploited land (Fig. 1.1). This and other aspects of the model are examined more fully below, but first it needs to be set against the background of the ecological and evolutionary paradigm that has strongly influenced recent approaches to understanding the emergence of agriculture.

Ecological and evolutionary approaches to understanding the emergence of agriculture

It was during the 1960s that models were first proposed in explicitly ecological and evolutionary terms to attempt to explain the transition from hunting and gathering (dependence on wild foods) to agriculture (dependence on domesticated plants and animals). The gradualistic view of that transition which was adopted by such ecologically minded students of the subject as Binford (1968), Flannery (1968, 1969), Harris (1969), and Higgs & Jarman (1969) can be traced at least as far back as Darwin's characteristically cogent description (1868, p. 309) of 'the first step[s] in cultivation'; but it only came to be widely accepted during the last twenty years. The contributions of these authors to the ecological-evolutionary paradigm need little rehearsal here, but it is worth signalling some of the changes in terminology which they introduced.

The new, more explicitly ecological orientation of the 1960s, which stressed the continuities rather than the contrasts between hunting and gathering and agriculture, was in part a reaction to the then prevalent view, derived from Gordon Childe's seminal concept of the 'Neolithic Revolution', of the transition to agriculture as a relatively abrupt event induced by

a climatic shift to greater aridity in Southwest Asia in the early Holocene. Childe contrasted the Neolithic 'food-producers' with the 'food-gatherers' of earlier times, but he did not distinguish conceptually between agriculture, cultivation, and domestication, although he used all three terms in his accounts of the Neolithic Revolution (Childe 1936, 1942).

The use of the term 'food production', as synonymous with agriculture, was further promulgated by Braidwood (eg. 1952, 1960), and has continued to the present. In the 1960s, particularly in two highly influential papers by Binford (1968) and Flannery (1968), it came to be contrasted with the term 'food procurement' which was applied to the food-gathering and food-collecting activities of hunter-gatherers. This tended, at one level of analysis, to reinforce the long-established dichotomy between hunter-gatherers and agriculturalists, but because both Binford and Flannery were exploring the transition to agriculture in systemic terms by postulating positive and negative interactions of particular environmental and behavioural variables, their papers also had the effect of emphasizing continuities that linked hunter-gatherer 'food procurement' to agricultural 'food production'.

A diminished emphasis on the dichotomy between hunter-gatherer and agriculturalist – or forager and farmer – within a systemic framework of analysis, was also implicit in my ecological approach to the study of the beginnings of agriculture in the tropics (Harris 1969, 1972, 1973). In particular, I proposed a distinction between the 'manipulation' of biotic resources which could lead to sufficiently sustained intervention in the breeding systems of wild plants and animals that 'domestication' resulted; and the 'transformation' of natural into artificial ecosystems which accompanied the later establishment of fully developed agricultural economies. Manipulation and transformation were thus envisaged as two phases on a gradient or continuum of ecological change induced by human modification of natural ecosystems, which led, in the remote past, from hunting and gathering through domestication to agriculture. I did not at that time, however, make any finer distinctions in terms of such variables as gathering, tending, planting, sowing, tilling, etc., nor did I distinguish conceptually between cultivation and agriculture.

It was during the 1960s that Eric Higgs and his associates at the University of Cambridge also sought to broaden the study of 'agricultural origins'. They redefined the objective as the study of prehistoric economies, regardless of whether such economies were predominantly of hunter-gatherer or agricultural type. Higgs argued that the archaeological record should be interpreted in terms of biological and economic principles, and ethnographic analogies, and he selected the term 'husbandry', in preference to domestication, to denote the whole spectrum of human intervention in and control over the biology and behaviour of animals and plants – intervention which, he postulated, reached back into Palaeolithic times (Higgs 1972).

By the mid 1970s these ecological and evolutionary approaches had brought about a transformation in how the study of early agriculture was

perceived: it was no longer viewed in isolation but in the broader context of prehistoric 'subsistence systems' or 'palaeoeconomics', and the formerly rigid dichotomy between hunter-gatherers and agriculturalists had become blurred. Since then, the attention of ecologically oriented students of prehistoric subsistence has begun to focus more precisely on the diversity and interconnections of the activities through which people have, in the past, exploited both 'wild' and 'domestic' plants and animals.

Theoretical contributions to this recent phase in the development of the ecological-evolutionary paradigm were made during the 1980s by Rindos (1980, 1984), Hynes & Chase (1982), Jarman *et al.* (1982), and Ford (1985). Their contributions relate directly but differently to the model proposed in this chapter, and they are, accordingly, briefly reviewed as a prelude to presentation of the model.

The third and final volume of the *Papers in economic prehistory*, in which Higgs and his colleagues reported the results of their research on early agriculture in Europe and Southwest Asia, appeared in 1982 after his death. In it, Jarman *et al.* looked back over the development of the Higgs' 'school' of palaeoeconomy and offered their revised formulation of its theoretical basis and methodology. They reaffirmed Higgs' distinction between domestication, in the strict sense of morphological change in plants and animals resulting from their selective breeding by humans, and the much broader concept of husbandry. They then went on to elaborate the distinction by proposing more complex classifications of both 'man-animal' and 'man-plant' relationships, as follows: for animals, six categories (random predation, controlled predation, herd following, loose herding, close herding, factory farming); and for plants, five categories (casual gathering, systematic gathering, limited cultivation, developed cultivation, intensive cultivation); stressing, however, that such classifications did not represent 'an economic ladder of progress, with one stage inevitably developing towards, and eventually into, the next' (Jarman *et al.* 1982, pp. 51-4). As we are concerned in this chapter with plants, it is also worth pointing out that they strongly endorsed Helback's original distinction (1960) between plant cultivation and plant domestication - a distinction which first introduced into the study of early agriculture the concept of 'pre-domestication cultivation' that has since been used effectively by Hillman (1975) and others.

A more comprehensively biological and ecological-evolutionary approach to 'the origins of agriculture' has been developed recently by Rindos (1980, 1984). In the context of this chapter, his major contribution has been to embed the concept of domestication within that of 'co-evolution', defined as 'an evolutionary process in which the establishment of a symbiotic relationship between organisms, increasing the fitness of all involved, brings about changes in the traits of the organisms' (Rindos 1984, p. 99). This approach - by which domestication is regarded as but one type of biologically defined symbiotic relationship - was originally introduced into the study of prehistoric domestication (of animals) by Zcuner (1963, pp. 36-64), and Rindos has extended and elaborated it, specifically in relation to plants and

agricultural systems. In so doing, he has proposed a new three-fold classification of 'the domestication relationship' consisting of 'three conceptually distinct aspects mediated by different types of human behaviour and occurring in distinct environments', i.e. 'incidental domestication' which is 'the result of human dispersal and protection of wild plants in the general environment'; 'specialized domestication' which is 'mediated by the environmental impact of humans, especially in the local areas in which they reside'; and 'agricultural domestication' which is the 'culmination of the other two processes, involves the further evolution of plants in response to the conditions existing with the agroecology' and 'is roughly equivalent to what has simply been termed *domestication* in the literature of agricultural origins' (Rindos 1984, p. xiv-xv). The classification is explicitly evolutionary, but, like Jarman *et al.* in respect of their classifications, Rindos denies that his scheme represents 'stages' in the development of all agricultural systems. He emphasizes that the three types of human-plant relationship are not mutually exclusive; indeed, that the boundaries between them are inevitably artificial because the three categories are 'components of an integrated, natural process' (Rindos 1984, p. 53).

Rindos' full discussion of his taxonomy of plant domestication (1984, pp. 152-66) represents the most comprehensive attempt (since Zcuner's for animal domestication) to broaden and systematize the ecological-evolutionary concepts which can be applied to the study of past (and present) people-plant interactions. In its comprehensiveness his taxonomy encompasses at a high level of generality the two other recent theoretical contributions already referred to - Hynes & Chase (1982) and Ford (1985) - although they differ from Rindos in some important respects. Hynes & Chase (1982) coined the term 'domiculture' to describe the interaction of people and biotic resources in local 'hearth-centred' environments or 'domuses'. They developed their ideas in the context of Australian Aboriginal attitudes towards, and uses of, plants, but the concept of domiculture has more general application. In ecological terms, it is equivalent to Rindos' category of incidental domestication (and in part also to that of specialized domestication), although Chase in Chapter 3 of this book objects to that equation, arguing that to see hunter-gatherers as 'incidental' domesticators is to beg the central issue - which, in his view, is the primacy of human sociality in initiating, articulating, and maintaining the production and distribution of resources. According to Chase, domiculture is the result of intentional human action focused on culturally recognized plants (and animals), and is not, as is Rindos' incidental domestication, a more general biological phenomenon which people share with other domesticatory organisms. However, with that important qualification, Hynes' and Chase's concept of domiculture does closely resemble - and could be said to fit as a subsidiary concept, restricted to human actions, within - Rindos' categories of incidental and specialized domestication. So, too, does the concept of 'agronomy' among Australian hunter-gatherers which Yen develops in Chapter 4 of this book.

In the Preface to his 1985 publication on *Prehistoric food production in North America*, Ford remarks that inclusion of the term husbandry in the original title of the seminar, held in 1980, on which the book is based – ‘The origins of plant husbandry in North America’ – was rejected on two grounds: that it implied ‘a skewed division of labor in favor of men’, and because it ‘customarily is applied to the management of animals’ (which as domesticates – except for the dog and the turkey – were absent in prehistoric North America); so, ‘following the lead of Braidwood in the Near East’ the term food production was adopted instead (Ford 1985, p. xii). This anecdote neatly illustrates the conceptual difficulties that have troubled students of prehistoric subsistence, and it raises echoes not only of Braidwood, but of Childe before him and of Higgs after him. Ford himself, in his introductory contribution to the book, outlines his own classification of the ‘stages and methods of plant food production’, (Ford 1985, pp. 2–7). He proposes two major successive stages: ‘foraging’ and ‘food production’, and divides the latter into two successive sub-stages: ‘cultivation’ and ‘domestication’. Three main methods of food production are recognized as succeeding one another: ‘incipient agriculture’, ‘gardening’, and ‘field agriculture’, and several types of human behaviour toward plants, viewed as a continuum of types of interaction, are added to the classification, namely ‘tending’, ‘tilling’, ‘transplanting’, ‘sowing’, and ‘plant breeding’. This sequence of behaviours or ‘cultural activities’ leads from the least biologically disruptive to complete domestication, when plants become completely dependent on humans for their continued existence; and the types of interaction are regarded as cumulative over time.

Ford’s scheme is a more comprehensive and detailed categorization of plant-food production than the other classifications discussed, and it does help to clarify the complex interactions between people and plants that are involved. However, although it is viewed by Ford as a continuum, it is not explicitly based on any stated variable(s), such as energy input or population density; although it is, by implication, related to time, to the degree of human disruption of plant biology and ecology, and, more implicitly still, to increasing cultural complexity and size of human populations. It resembles in some ways the model of people-plant interaction presented in the next section – although when constructing early versions of that model some years ago I was unaware of Ford’s scheme – and the two classifications certainly share the twin aims of attempting to clarify the concepts we use when investigating the prehistory of plant exploitation, and of specifying more precisely the relationships of those concepts along a continuum of people-plant interaction.

The model: an evolutionary continuum of people-plant interaction

As has been stated in the introduction to this chapter, the model summarized in Figure 1.1 is based on ecological and evolutionary assumptions, but it is

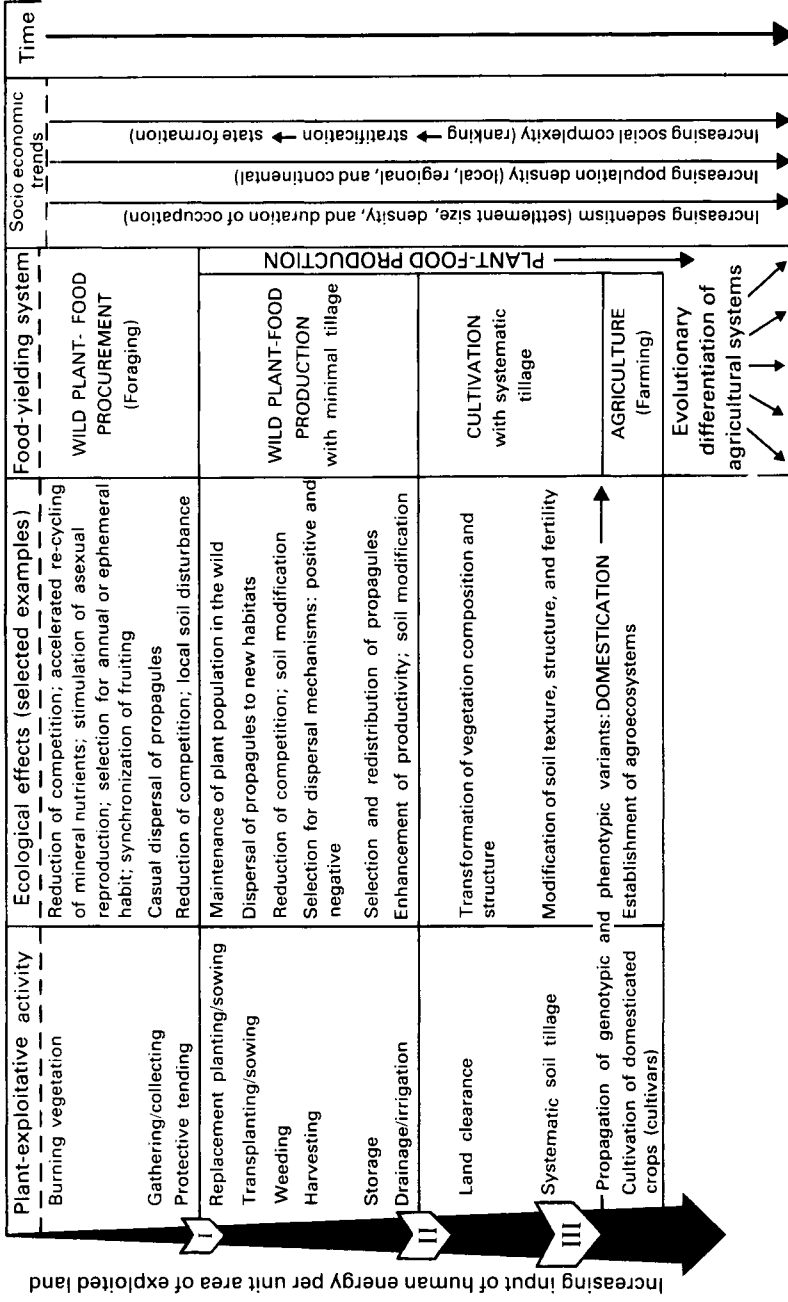


Figure 1.1 Schematic diagram of an evolutionary continuum of people-plant interaction (the Roman numerals indicate postulated energy thresholds).

not unidirectional and deterministic. It does not address the question of *why* some past human societies shifted from primary dependence on wild plant foods to primary dependence on cultivated crops. It seeks only to specify a series of plant-exploitative activities and associated ecological effects arranged sequentially along a continuum which is, however, also conceived as a gradient of increasing input of human energy per unit area of exploited land. This correlation cannot at present be demonstrated quantitatively and must remain hypothetical. It rests, in turn, on the assumption that there has been, over time, a positive relationship between energy input into food procurement/production and energy output measured in terms of the calorific value of the harvested and processed plant foods. However, I make no attempt here to answer the underlying question of whether the suggested trend of increasing energy input and output per unit area of exploited land was a function – in any given situation in the past – of increases in human population density, in sedentary settlement, in social stratification, or in other socio-demographic factors, in varying systemic combinations. The aim is to present a descriptive not an explanatory model, except in so far as the posited correlation with energy input can be regarded as ‘explanatory’.

In Figure 1.1 the human activities specified are based on ethnographic observations and historical accounts of interactions between people and the plants they exploit for food, and it is presumed that these activities had prehistoric antecedents which, to varying degrees, may be archaeologically traceable. Although the activities, from burning vegetation to the cultivation of domesticated crops and the differentiation of agricultural systems are presented as sequential, it is not implied that they succeeded *and replaced* one another over time, except in the very general sense of comparative importance on a world scale. To put it another way, all the specified activities are still practised today in agricultural, and, to a reduced extent, in non-agricultural contexts (environments), but as agriculture progressively replaced gathering (and hunting) as the predominant food-yielding system, so the relative importance of those activities by which wild plant foods were exploited declined. Activities such as planting and sowing, harvesting and storage, irrigation and drainage, land clearance and tillage, which are assumed to pre-date agriculture (as here defined), were, of course, incorporated into evolving systems of cultivation and eventually became highly elaborated, integral components of agricultural production. Likewise, the burning of vegetation was incorporated as an essential technique into certain agricultural systems, notably shifting or swidden cultivation, and the protective tending of ‘naturally’ occurring useful plants anticipated the weeding of intentionally planted or sown crops. Even the gathering of edible parts of ‘wild’ plants has persisted as a minor, but sometimes dietarily significant, activity in developed agroecosystems.

Given the above qualifications, Figure 1.1 is intended to represent a gradient as well as a continuum of progressively closer people-plant interaction. Along it, the input of human energy per unit area of land exploited for plant foods increases, and so too does the modification of

'natural' ecosystems, and their replacement by agroecosystems, which results from that energy input. The gradient of interaction extends from the (relatively) spatially diffuse activity of burning vegetation, through the more localized gathering, collecting, and protective tending of wild plant products, to the planting, sowing, weeding, harvesting, and storing of (undomesticated) crops, with associated irrigation and drainage, land clearance, and tillage, eventually to crop domestication: this latter condition having come about (according to the orthodox criterion of domestication accepted here) when the reproductive system of the plant population has been so altered by sustained human intervention that the domesticated forms – genetically and/or phenotypically selected – have become dependent upon human assistance for their survival. Figure 1.1 makes a distinction between cultivation, as a method of plant-food production which incorporates land clearance and systematic tillage but which can be (and in the past widely was) applied to undomesticated crops, and agriculture, which term is restricted to the cultivation of domesticated crops. I readily acknowledge that the distinction between undomesticated and domesticated crops is not absolute, if for no other reason than that the genetic/phenotypic selection processes leading to domestication are cumulative, but the distinction between cultivation and agriculture proposed here is at least clear, and it has the added merit of making redundant the vague (and by implication deterministic) category of 'incipient agriculture'.

It will be apparent that I have not introduced the term 'horticulture' into the model. It could have been equated with agriculture or regarded as a distinctive type of agricultural system in order to distinguish between small-scale garden cultivation or *gartenbau* and larger scale field cultivation or *ackerbau*. But, although that is a valid and useful distinction to make when discussing the evolution of agricultural systems, it raises at least two definitional difficulties. The first arises from the fact that in some of the literature on agricultural systems and their evolution, particularly much of that which relates to Melanesia and the Pacific Islands, the term horticulture or 'gardening' has come to be used as a synonym for agriculture (e.g. Groube Ch. 17, this volume; Jones & Meehan Ch. 7, this volume) rather than as a means of distinguishing between 'field' and 'garden' cultivation.

The second difficulty is more problematic and arises from the distinctive ecology of 'house' or 'door-yard' gardens to which Anderson first (1952, pp. 136–42) and Kimber later (1966, 1973, 1978) drew particular attention. Investigation by Kimber of present-day 'traditional' gardens in Puerto Rico and elsewhere revealed that nearly 50 per cent of the plant species present in them were adventitious wild and weedy taxa rather than domesticated crops, although almost all the taxa were perceived by the owners of the gardens as making useful contributions to the household economy. This situation contrasts strongly with the ratio of wild and weedy taxa to domesticated crops that tends to characterize field cultivation, even in situations where within-field mixed cropping rather than within-field monoculture is the norm. House gardens characteristically combine the cultivation of domestic-

ated crops with a significant component of wild plant-food production, and indeed, as I have previously suggested (Harris 1973, pp. 398–401), they probably functioned in the past as important arenas for plant domestication. Therefore, if the term horticulture *is* to be used to denote small-scale garden cultivation involving the exploitation of almost as many 'wild' as domesticated species, than it should not be equated with agriculture but instead regarded as a distinctive type of agroecosystem.

It is not necessary in this discussion to exemplify from ethnographic and historical sources all the plant-exploitative activities listed in Figure 1.1. Many of the contributions to this book do so in considerable detail, particularly in Chapters 5–19, e.g. the replacement planting of yams and the incidental 'tillage' of yam grounds in Australia referred to by Hallam, Jones & Meehan, and Yen; the transplanting of acorns in southern California mentioned by Shipek; and the sowing, harvesting, and processing of wild-grass seeds in southern California, North Africa, and Australia described, respectively, by Shipek, Harlan, and, for Australia, by Cane, Jones & Meehan, Smith, and Yen (see also Allen 1974). There are fewer references in this book to the burning of vegetation to enhance the yields of plant foods and to make their gathering easier (but see Yen for a summary discussion of Australian Aboriginal use of fire to promote the productivity of cycads, grasses, and tuberous plants), and still fewer to non-agricultural contexts in which irrigation and drainage were applied to the exploitation of wild plants to regularize and increase harvests – probably the best-known example of which is the relatively large-scale irrigation of grasses and tuberous plants (such as *Cyperus esculentus*, cf. Hillman Ch. 13, this volume, pp. 226–7) which was practised in historical times (and perhaps earlier) by the Paiute Indians of Owen's Valley in eastern California (summarized in Harris 1984).

It has already been suggested that the sequence of plant-exploitative activities in Figure 1.1 represents a gradient of increasing input of human energy per unit area of exploited land. It can now be further suggested that, qualitatively at least, we can envisage thresholds along the gradient which represent stepped increases in energy input, at which points markedly more effort is invested in selected areas of exploitation, and human intervention in the ecology and reproductive biology of particular plants intensifies. Three such thresholds are postulated in Figure 1.1. The first is between the spatially diffuse and low-energy activities of burning, gathering, and protective tending, and it can be said to separate the food-yielding system of 'wild plant-food procurement' or 'foraging' from 'wild-food production'. The second is between the more spatially focused, labour-demanding, and ecologically interventionist activities that range from planting and sowing to irrigation and drainage, and the still more energy-intensive activities of land clearance and systematic tillage.

The second threshold separates 'wild plant-food production' from 'cultivation'. This is seen as a crucial threshold because, once land clearance and tillage is practised regularly on more than a very small scale, the energy-input demands of the system increase substantially. The biblical injunction



Figure 1.2 The beginning of agriculture, according to Larry Gonick (© Larry Gonick, all rights reserved, reproduced with his permission).

(Genesis 3:17–19) is indeed true, that ‘In the sweat of thy face shalt thou eat bread’, or, as Rousseau (1755) ironically described the beginning of agriculture when ‘vast forests were changed into smiling fields which had to be watered with the sweat of men’. Larry Gonick (1978) makes the same point (Fig. 1.2) visually but equally emphatically! The separation of cultivation from wild plant-food production by the second energy threshold may appear somewhat arbitrary, in that transplanting, weeding, and drainage and irrigation all involve some degree of soil disturbance, but, in the context of wild plant-food production, such disturbance amounts to no more than minimal tillage, and does not undermine the contention that systematic clearing of the land and tilling of the soil (presumably initially by digging stick or hoe rather than by plough) require much greater investment of energy.

We can, then, define cultivation as a combination of systematic land clearance and tillage with the planting or sowing (as well, of course, as

harvesting, etc.) of undomesticated crops. Its inception marks an important point on the evolutionary continuum of people-plant interaction, but it does not necessarily lead to domestication. Crop domestication (in the narrow orthodox sense), or at least the adoption from elsewhere of already domesticated crops, is, however, a necessary component of agriculture. And, in so far as the cultivation of domesticates, if successfully developed and maintained, required that additional effort be devoted to such activities as soil preparation, the maintenance of soil fertility, weeding, seed selection and storage, and the exclusion of potential predators attracted by the enlarged food-storage organs of domesticated plants, then the division between cultivation and agriculture can be said to constitute a third energy threshold on the continuum.

Although only three energy thresholds are postulated in Figure 1.1, we could of course define further thresholds *within* the general category of agriculture which would separate different agricultural systems – such as horticulture, swidden cultivation, floodwater farming, irrigation agriculture, mixed grain-livestock farming, etc. – along the gradient of increasing energy input: an elaboration of the model which is, however, not attempted here.

In characterizing the interaction continuum as a gradient of increasing input of human energy, and postulating thresholds along it, I here disregard the question of how that input was provided, e.g. by a larger population and/or by changes in the sexual or age-related division of labour and/or by changes in the seasonal scheduling of activities. These are important but subsidiary aspects of the present model, which deliberately adopts as an organizing principle the key variable of increasing input of energy per unit of exploited land. Nor do I explore possible correlations between the energy gradient and such socio-demographic trends as increasing sedentism, increasing population density, and increasing social complexity: all aspects of what has recently come to be referred to by some authors as the process of 'intensification' (cf. Lourandos 1983; Yen Ch. 4, this volume). It is sufficient here just to portray them in Figure 1.1 as assumptive correlations only. The variable of time is treated similarly in Figure 1.1, because any attempt to attach a scale in millennia to the continuum requires more knowledge than we presently have of the chronology of plant exploitation. Such a calibration might, however, usefully be attempted for those few regions of the world, such as parts of Southwest Asia, Europe, Middle and North America, where we are beginning to assemble a chronological overview of the evolution of plant exploitation.

The last aspect of the model which calls for comment here is the question of its utility – or lack of it. As stated at the start, my main aim is to help clarify the general terminology we use in thinking and writing about the emergence of agriculture. It is hoped that the model has at least logical validity and some theoretical value, but, if it is to prove useful in investigating the actual history and prehistory of plant exploitation in particular geographical regions, more comprehensive means than we have at present will have to be

devised to trace in the archaeological record the range of plant-exploitative activities that make up the continuum. At present, relatively few of those activities are open to direct archaeobotanical or palaeoenvironmental investigation.

Palynology, and the less advanced technique of the stratigraphic analysis of charcoal frequencies, can provide some information on land clearance and fire history. Phytolith analysis, too, is proving a promising technique for the investigation of vegetation change and crop history. The most important set of techniques, however, are those that are applied to the study of macroscopic plant remains preserved by charring, mineralization, water-logging, and desiccation. Thus far they have been applied principally to the investigation of domesticated seed crops, particularly the staple cereals of modern agriculture, maize, wheat, barley, and rice; much less so to pulses (but see Butler Ch. 24, this volume) and other non-cereal seed crops, and hardly at all to root and tuber crops. New chemical and anatomical-micromorphological techniques are now being developed which may open new avenues to the identification of the remains of roots and tubers (Hill & Evans Ch. 26, this volume; Hather 1988) and there is also growing interest among archaeobotanists in the investigation of pre-agrarian plant exploitation (see the contributions to this book by Costantini, Hillman, Hillman *et al.*, Pearsall, Piperno, and Pyramarn).

Field archaeology can sometimes provide direct evidence of irrigation (e.g. Oates & Oates 1976) and of drainage systems in swamp environments (e.g. Golson Ch. 44, this volume), and it is beginning also to reveal the capacity of some prehistoric agriculturalists for large-scale landscape modification by mound and terrace construction, etc. (e.g. Gallagher Ch. 36, Bulmer Ch. 45, this volume). But in the absence of surviving traces of such features in the landscape, it is extremely difficult to demonstrate whether such activities as irrigation, drainage, and tillage were practised. A new experimental approach to the question of tillage is currently being developed by Unger-Hamilton (in press) who has combined harvesting experiments on a range of Southwest Asian wild grasses and other herbaceous plants with microwear studies of flint sickle blades. It appears that striations on the blades may be attributable specifically to the harvesting of plants growing on tilled as opposed to untilled soils. If this is confirmed by more comprehensive experiments, the technique could provide us for the first time with a direct method of determining, at least in parts of Southwest Asia, how long ago soil tillage was practised and thus of tracing the beginnings of cultivation (as here defined).

There are therefore a variety of methods, some well established and others highly experimental, for investigating several of the activities that make up the continuum of people-plant interaction outlined here. In presenting it, I emphasize that it is highly schematic and tentative, but I also hope that it may help to clarify our thinking and assist future enquiry into the theme of this book: the evolution of plant exploitation from foraging to farming.

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2 *Darwinism and its role in the explanation of domestication*

DAVID RINDOS

**Dedicated to the memory of
Michael E. Whalen**

‘he was a scholar, and a ripe and good one’

Henry VIII

Introduction

Anthropology has long been pre-eminently a discipline unto itself. It has separated itself from its sister social sciences by acceptance of the rather sublime observation that humans are, at least in some sense, animals, mammals, and primates. Divorce from the biological sciences has been uncontested and amicable. Anthropology has been able to provide the grounds for the divorce by providing expert testimony on how humans are totally unlike the rest of creation. And, in providing itself with the justification of its own existence, it has provided the rest of biology with defences for continued belief in the fundamental difference between our own species and the rest of the animal kingdom. In a rather rare instance of interdisciplinary co-operation, anthropology has been able to provide biology with all the reasons necessary to maintain an unquestioned and unquestioning acceptance of the incommensurability of one species with all others. One might expect a critical mind to note the self-serving nature of the argument and question it on those grounds if no other.

The fundamental and underlying rationale for compartmentalizing the study of human behaviour in a separate discipline may best be understood by appreciating the role given to a specific type of ‘cultural’ process in the explanation of human behaviour. Humans, it is held, are cultural animals. Human culture, however, is seen as the means by which humans *consciously and intentionally* adapt to a multitude of environments. Here, intentional adaptation effectively removes humankind from the materialistic and mechanistic processes that govern other natural processes. My purpose in

this chapter is to attack this central belief. In it I defend the idea that cultural processes are natural; that cultural change is best understood by means of a natural process. Darwinian evolution provides the theoretical backdrop for the approach that I advance, in place of intentional cultural adaptation and adjustment; change in subsistence patterning provides the context for the discussion.

My intent here is to shed some light on a central problem in human cultural change – the evolution of agricultural systems – by looking at human culture and cultural change in a different way. I do not criticize in this chapter earlier models for cultural evolution, whether in general or specifically in terms of agricultural origins (see Rindos 1984, 1985, 1986). Instead, I focus upon agricultural change using a specific Darwinian model – the ‘cultural-selectionist’ view of culture.

Cultural selectionism is based upon three interrelated postulates.

- (a) The human capacity for culture (and the innate morphologies and psychological processes thereby implied) has evolved by means of natural selection. Humans are not cultural because they choose to be cultural; instead the capacity for culture may only be explained in terms of the enhanced fitness that it induced in those hominids who had a greater capacity for cultural behaviours.
- (b) The same processes which originally brought about the genetic capacity for culture in humans, continued, and indeed continues, to act upon the specifics of cultural acts, beliefs, and structures. Here, natural selection is the ordering force in non-genetically transmitted cultural phenomena. It is important to note that cultural selectionism, in contradistinction to sociobiology, holds that, while human culture taken as a whole is genetically permitted, *none* of the differences existing between human cultures may be explained on the basis of genetic differences between members of those cultures. Instead, these differences arise as the result of differing selective pressures experienced by various human cultures during their history.
- (c) In contrast to the ‘evolutionism’ of Spencer, White, and Sahlins & Service, cultural selectionism posits a strictly Darwinian model for cultural function and change. Here the most significant statement of cultural selectionism is that no inherent direction underlies cultural evolution and that, instead, all change is the result of selection acting upon the undirected variant cultural forms existing at earlier points in time.

The Darwinian perspective on plant domestication and agricultural evolution

Darwinists hold that evolutionary change results from the natural selection of heritable variation. Ernst Mayr has repeatedly pointed out (e.g. 1942, 1969, 1982, pp. 519–20) that Darwinian evolutionary change is based upon a

two-step process: (1) the production of undirected variation, and (2) its sorting by means of the differential success and failure of various forms over time. In this, Darwinism, unlike any other evolutionary theory, places major emphasis upon the *undirected nature of the processes generating variation* in heritable traits. Yet, in saying this, it is essential to stress that the Darwinian concept of undirected variation does not hold to the absurd claim that variation is generated 'randomly' in the mathematical sense of that term, i.e. that the process is totally stochastic and unbounded. Clearly, no human will exhibit variation in wing structure or photosynthetic pathways. Instead, variation at any moment in time will always be bounded in very important ways by the nature of the organism itself, i.e. by its evolved history.

An example stressing the historicity of Darwinism may be seen in the process underlying the earliest beginnings of plant domestication. As I have pointed out (1984), a simple relationship exists between humans and the plants on which they feed. Over long periods of time, human feeding behaviour will alter the local flora in such a manner as to place certain morphological traits of members of a plant species at a competitive advantage over others. This competitive advantage arises in terms of how effective a particular morphology is in attracting human consumers as dispersal agents for the plant. The further evolution of the plant species, therefore, will be altered by the feeding and dispersal behaviour of humans (cf. Chase Ch. 3, Harris Ch. 1, this volume). Yet this evolution, in any specific case, takes place in the context of two interdependent historical processes – that of the plant genome, including mutation and recombination, and that of the learned subsistence behaviour of the humans. A subsistence pattern that lacks a particular behaviour, for example the processing of tubers for starch, will place limits upon the development of specific domestication events quite as effectively as the non-appearance of an 'appropriate' genetic event within the plant. Hence, we must recognize that speaking of the general evolutionary pressures within the development of agricultural systems may only sensitize us to the types of symbioses that might have occurred; it cannot replace the careful study of the particulars that have occurred in any specific system (as exemplified by many contributions to this volume, e.g. by Chikwendu & Okezie, Johns, Ladizinsky, Pearsall, and Zohary).

The possible direction of evolution will also be affected by the peculiarities of the specific transmission system that codes for variation. The nature of the coding system is of major importance when we discuss any evolutionary process. For example, the effects of recombination during evolutionary change must be explained with a sensitivity to the fact that different organisms may have radically different types of recombination options open to them. Prokaryotes (bacteria and their allies) may exchange variable amounts of genetic information during 'mating', while eukaryotes ('higher' organisms) are generally forced by the existence of true sexuality and meiosis to contribute equal amounts of information to individuals of the next generation. In the same manner, information that is coded and transmitted genetically will have different evolutionary potentialities and limitations

than information affecting the organism's behaviour that is transmitted directly from one phenotype to another (i.e. 'culturally' in the broadest sense of that term). Hence, we may see that while variation does not exist independently of organisms, organisms do not exist independently of their evolutionary history. This is true both in terms of the types of traits that may vary and also in terms of the inheritance systems that transmit traits, and their variant forms, between organisms over time. Yet, when we wish to explain changes in traits existing in biological entities, an understanding of the evolved peculiarities of organisms is literally the object of our inquiry. Therefore, we will expect that our understanding of evolution must be informed by the peculiarities of the specific inheritance systems of the organisms we are studying.

In this context, the properties of the cultural transmission system that governs variable human behaviours must be taken into account when we seek to understand the origin and evolution of cultural traits. Here, much useful work has already been done by Cavalli-Sforza & Feldman (1981) and Boyd & Richerson (1985). Cultural change may profitably be analogized with genetic evolution (Campbell 1965, 1976). For example, innovations appear in populations, and spread if favoured or are abandoned if not, by processes showing striking similarities to natural selection and random drift. Nevertheless, we must recognize that these sorts of general descriptions are only a heuristic model and that the explanation of specific cultural changes must take into account the specifics of the system being considered. Secondly, and of greater importance, we must stress that transmission processes should not be confused with evolutionary ones. Transmission mechanisms may indeed place biases upon the possible direction of evolution (Boyd & Richerson 1985), but the changes that *have* occurred in cultural evolution 'are hardly made intelligible by the transmission modes, but rather by examining the interaction between demography, environment, technology, and organizational variables' (Marks *et al.* 1983, p. 15).

Plant domestication and prehistoric agriculture in the American Bottom

For an example of this type of interactive analysis, we may consider work that has been done on domestication and the origins and further development of agricultural systems in an area of the central United States known as the American Bottom (Rindos & Johannessen 1988 and cf. Watson Ch. 35, this volume). Following a long period of 'incidental domestication' (Rindos 1984, pp. 154–8) of several species of nut-bearing trees, a complex of starchy and oily seeded native plants began to grow in importance in this region during the Middle Woodland period (c. 150 BC–AD 300). The contribution of this complex of seed plants to the diet increased, in both absolute and relative terms, until the latest phases of the Mississippian period (AD 1000–1500). At about AD 800, maize begins to appear in the archaeobotanical record from the region, with the evidence indicating a widespread and remarkably abrupt adoption of this imported plant. Yet, the fact that the

starchy seed complex remains abundant in the record, despite the introduction of maize, indicates that this new crop was not grown *instead of* the existing plant complex, but *in addition to* plants that had been part of an evolved agricultural system with humans for as much as 1000 years. Furthermore, the speed at which maize appears in the record is remarkable. Seeds and cobs, often in very substantial quantities, have been recovered from 50 per cent to 90 per cent of the features analysed at sites of the Emergent Mississippian period (AD 800–1000). In the sites dated to the immediately previous phase, maize is virtually unknown, having been recovered in minute quantities from only 2 per cent of the features analysed. The data clearly indicate that the appearance of maize in the record marks the introduction of a new crop rather than the appearance of agriculture itself.

The most parsimonious explanation for the rapid rise of maize in importance in the area holds that while maize had been present for a very long time in the region, it was represented by soft-seeded varieties that were grown for their immature cobs. The Mississippian maize horizon represents not the introduction of the species itself into the area, but rather the appearance of a new variety having hard seeds that were used in the mature form. In the context of this discussion, it is important to note that the diffusion of this new, hard-seeded variety of maize into the region could not have been successful unless humans were already practising the necessary agricultural behaviours. Hence, the spread of the new crop was not in any sense a 'random' event based upon any inherent qualities of the maize plant, but was preconditioned by the existence of an already functioning indigenous agricultural system.

As has been stressed, the Darwinian view of cultural change does not claim that the variant forms upon which selection was to act over time had to be generated in a totally 'random' manner. We need not claim that specific human characteristics such as decision-making, experimentation, or cultural bias must be excluded from consideration in understanding the genesis of the original variant behaviours that were to form the foundations for the evolution of new cultural traits. We need only claim that these processes *in and of themselves* were insufficient to generate the evolved systems.

Adopting a Darwinian perspective involves a reorientation of our thought processes. Rather than concentrating upon the *origin* of the particular variant trait that was to form the basis for future developments, we stress the *effect* the possession of this trait, in its incipient form, was to have upon humans and their cultures. Here our attention is directed to the fact that all cultural behaviours have some influence, no matter how small, upon human survival and reproductive success. This will be true even if changes in these behaviours are completely independent of any change in gene frequencies in the populations under consideration. Put in other terms, cultural behaviours may affect human demography. Hence, the concept of 'pure' or 'demographic' Darwinian fitness is wholly applicable to the effects of cultural traits upon human populations.

Let us return to the introduction of maize into the American Bottom. We

have already noted that it was introduced into a cultural and agricultural system that had been in operation for at least a millennium. Nevertheless, following its adoption, major changes may be seen in the archaeological record. These include increases in population, nucleation, social complexity, and centralization. We have argued (Rindos & Johannessen 1988) that some of these changes were precipitated by the introduction of the storable form of maize which, by means of its higher yield potential, permitted increases in populations in the region. Of greater importance, however, is the possibility that the qualities of the varieties of maize that came into use may have had major effects upon the reliability and predictability of the agricultural system itself, and hence upon the social structuring of the region.

As population increased as a function of the higher average yield obtainable from maize, so did the need for farm land. Increased farm land could be obtained only by clearing the native forests. Our evidence indicates that this occurred, at least in part, by clearance of the incidentally domesticated 'nut groves' that had arisen over many centuries in regions of human habitation. A major change occurs in the charcoal record when maize appears as a major component of the diet. Before the introduction of maize, most firewood was from soft-wooded genera such as *Populus* (poplars) and *Salix* (willows). The burning of hard-wooded genera such as *Carya* (hickory) and *Juglans* (walnut) appears to become common only after maize becomes abundant, with charcoal from these species appearing for the first time in the archaeological record in large quantities.

We should note that, all other things being equal, the hard woods make a better source of fuel for both cooking and heating than do the soft woods. Yet despite this, soft-wooded genera were utilized preferentially throughout the pre-maize periods. We assume that the nut trees were originally valued more for their mast crops than as a superior source of firewood. We might also note that culinary change involving a new need to cook the maize as a gruel cannot be invoked to explain this change in patterns of wood utilization. Braun (1983) has tied changes in ceramic technology during pre-maize periods to the demands placed upon the vessels in response to the increasing use of cooked starchy and oily seeds in the diet. Hence, we cannot explain the change in wood utilization as a response to new cooking requirements. We might also note, in passing, that acceptance and integration of the new variety of maize into the diet might also have been facilitated by a pre-existing procedure for the preparation of the dried, starchy seeds.

It follows that the most logical explanation for the change in charcoal would be population pressure. The growing need for land on which to grow maize to support a burgeoning population probably brought about the destruction of what had previously been an important dietary resource – the mast crops harvested from nut trees. We should not lose sight of the fact that this destruction of resources probably represents the loss of a valuable oil and protein supplement in a region that lacked both domesticated animals (save the dog which was little consumed) and domesticated sources of plant and animal fats.

Much data indicates that while maize is higher yielding in the region than the native complex of starchy seed crops, this increased yield is probably accompanied by a radical increase in the variability of that yield, i.e. even though average yield obtainable from maize cultivation increases dramatically, the year-to-year variance on yield increases even more. It must be stressed that any change in absolute yield is 'progress' only at the moment of its first occurrence; over relatively short periods of time increases in yield will literally be eaten up by the increased populations they generate. Yet, as population increases, the negative effects of increased variability on yield become increasingly severe: one cannot consume during times of scarcity the no longer existing surplus that had been generated during times of abundance.

The most obvious way to deal with the interacting factors of increasing population, increasing potential yield, and increased variance in that yield would be an attempt to buffer the system by increased association and trade within and between regions. Then, if a crop is bad in one locality, maize could be imported from other localities during the crisis period. This is a type of activity that requires no foresight, merely a response to a specific condition of immediate reduced food availability. Furthermore, over time such arrangements could grow and have consequences that were totally unforeseeable at the moment that the exchange systems were initially established. Thus, the increased centralization and integration characteristic of Mississippian culture may be traced to attempts to deal with the new variability in yield characteristic of a maize-based agricultural system.

The evolution of agricultural systems

There is no doubt that agriculture, and changes in agricultural systems, may have major effects upon local demography and these, in turn, may affect social systems in radical ways. However, it is significant that differential fitness, the 'currency' of evolutionary change, requires that more than one state may be observed in the population of concern. If all individuals have exactly the same set of traits, evolutionary change is, by definition, impossible, because no differential fitness associated with specific traits can exist when only one set of traits exists. Cultural processes may be of major importance in determining which traits are acceptable to members of a culture. Therefore, a Darwinian view of cultural evolution does not restrict itself solely to the demographic aspects of cultural behaviours, but must also look inside the system and consider the impact of variable, culturally defined behaviours upon the further evolution of the system. I have dealt elsewhere with this distinction between the 'demographic' and 'symbolic' aspects of cultural-transmission systems under the rubric of cultural selection of the first and second types (CS₁ and CS₂: Rindos 1985).

Redirection of our thoughts to a Darwinian perspective requires a reinterpretation of most of our preconceptions regarding cultural practices and beliefs. We have generally seen the meaning of human innovations solely

in terms of their *causal* role in cultural evolution. I claim that these innovations are better viewed as events that *facilitate* evolution. The distinction is of major importance. And again, I will draw upon a genetic analogy. Provine (1983) has recently reviewed some aspects of the development of Sewall Wright's genetic theorizing, and he provides a useful account of the changing interpretations given to Wright's theory of genetic drift. He notes that when Wright first proposed genetic drift in the late 1920s and early 1930s it was widely adopted to explain what appeared to be 'adaptively neutral' differences between species. However, with the development of the 'New Synthesis' in the 1940s and 1950s, it was discovered that many of these traits, in fact, were of adaptive significance. Given this change in intellectual atmosphere, Provine notes that Wright

could now emphasize the view his shifting balance theory had incorporated from the very beginning – that random drift served the important function of providing novel genetic interaction systems upon which natural selection could act to yield more rapid progress of adaptive evolution than could occur under mass selection alone (Provine 1983, p. 65).

Hence, the significance of random genetic drift is not that it *causes* evolution, but that it *facilitates* evolution. Likewise, cultural processes such as innovation or discovery are processes that *permit*, but do not directly cause, cultural change. In the case under consideration here, the true reason for cultural change may be detected only in the social and demographic consequences of agriculturally induced changes in environment and behaviour.

As should be apparent with a little reflection, the manifold variations produced in any cultural setting can explain nothing in and of themselves. If we were to claim that a given change in subsistence patterning resulted solely from a change in a cultural pattern, we have, in fact, explained nothing. We have merely recast the problem in new terms. Instead of wondering why the subsistence pattern changed we must now query why the culture changed. We cannot use the evolved capacity of humans within a cultural setting to respond to the environment as explanation for the specific cultural changes that have occurred within a given historical setting. To explain the specific we cannot merely invoke the general; instead, we should seek insights by investigating directly the system itself that is of interest.

Consider another example from the American Bottom. As already noted, it is likely that the 'introduction' of maize around AD 800 into the region actually marked the appearance of new varieties of flinty, early maturing maize which were stored as dry grain. Previously, it is likely that maize was grown for its immature ears which were stored in a processed form. Here, culinary and storage techniques and traditions interacted to affect the growth potential of the agricultural system. If a crop is stored in a processed form, the seed needed to plant the next year's crop must be estimated and left unharvested until it is mature. In a year with a particularly good crop, much

food could be preserved and this could serve as a buffer against unpredictable reductions in other resources. Of course, the same can be done if the crop is stored as a dry grain. However, the potential growth rates of these two systems would not be the same.

Consider years of abundance: the stored crop is not consumed in its totality. If the stored crop were in a processed form, some might even end up going to waste. But if the stored crop were a dry grain, an alternative exists – planting of some of the left-over grain, increasing the area under cultivation by a slight amount. In this manner, potential mean productivity could rise as the result of a succession of favourable years. Storage of a crop in its reproductive form may increase the potential rate of growth of the system. However, this same identity of ‘food’ and ‘seed’ would have negative effects during bad seasons. Under conditions of moderate stress, some of the seed grain for the next season’s planting could be consumed. Here, the farmer is willing to take a gamble that next year’s crop will be sufficiently good that it is worth risking consuming some portion of the seed in the face of present needs. Of course, this is a risky tactic, in that it reduces the long-term stability of the system. And it is important to note that such a reduction in stability is far less likely to occur when the crop is stored in a processed form: a cultural and culinary marker sets the processed, ‘edible’ food apart from the ‘seed’. In the most extreme form, the edible part of the plant is totally differentiated from the reproductive part both culturally and biologically (for example, manioc and many other tropical tubers). Here the much discussed stability of tropical systems of root-crop cultivation (cf. Hawkes Ch. 31, this volume) may be seen, in part, as a function of cultural classification systems concerning what is edible.

Fitness and relative, limited adaptation

The distinction between culture seen as explanation and culture seen as the result of natural, evolutionary processes is neither trivial nor purely definitional. Instead, adopting the Darwinian perspective completely changes the manner in which we approach the historical, ethnographic, and archaeological records. It is not an easy point of view to adopt. Much of the aversion to treating cultural processes as natural arises from a cultural bias (Rindos 1985), and is largely centred upon the issue of the potency of human intentionality in explaining cultural change (Rindos 1984). Translated into evolutionary terms, the common-sense view of cultural change holds that *the variations are generated as specific responses to adaptive needs – i.e. that the variations arising in cultural systems are directional, and therefore the variations themselves, not selection, order evolutionary processes in human culture.*

This observation is of great importance for the understanding of cultural processes, in that it completely eliminates any need to presume an adaptive function for all cultural traits. Traits, of course, may be adaptive but this is a result of the fact that they gave a relative advantage to the individuals with

these traits. Here we analyse cultural traits in exactly the same terms used for the evolution of adaptations within any species. But we must also be willing to go beyond this analysis. Cultural traits may spread not because they are adaptive to some need but because they indirectly increase the relative fertility (fitness in the pure Darwinian sense) of individuals within a cultural setting. If, for example, religious affiliation is strongly transmitted from one generation to the next, then we can expect that over time (and all other things being equal) the proportion of individuals within any group belonging to 'procreative' religions such as Islam, Roman Catholicism, Orthodox Judaism, and Mormonism will rise. It is absurd to call any such change in the proportions of individuals belonging to these sects a result of an 'adaptation' by its members to any environmental 'need' or, put in other terms, that a positive correlation between relative fitness and environmental adaptation must always exist.

In a previous discussion of the spread of agricultural systems (Rindos 1984), I maintained that fitness and 'adaptiveness' may even show a negative correlation. The relative fitness induced in a culture by means of its agricultural behaviour is seen as being simply the result of a higher realized rate of population growth – agricultural behaviours increase the carrying capacity of the local environment for humans and, hence, the proportion of individuals per unit area who will have agricultural modes of subsistence will inevitably be larger than the proportion of individuals with most other subsistence strategies. It is important to realize that this will hold true even if agricultural behaviours bring with them a decrease in robustness, a decline in life expectancy, an increase in morbidity and mortality, or a higher infant mortality rate (accompanied, of course, by an even higher fertility rate). While all of these factors may easily be judged as indicators of decreased adaptation, the higher growth rate of agriculture will nevertheless favour it over other forms of human subsistence.

A very striking example of how fitness and adaptiveness may become decoupled may be seen by considering the relative fitness of competing agricultural traditions. Begin with the assumption that agricultural behaviours bring with them a decrease in overall 'adaptiveness' of human populations (as measured by the types of parameters mentioned above). Consider two competing agricultural populations, one of which has a more adaptive agricultural tradition than the other, measured in terms of variables such as stability in average yield. It is easily demonstrated (Rindos 1984, pp. 254–85), that, on the average, decreased stability in productivity will increase the probability that a given agricultural tradition will spread. Here, instability in agricultural production serves as a driving force in spreading a particular agricultural tradition by literally driving out individuals to colonize new regions. Occasional episodes of lowered productivity, induced not by the environment but rather by the plants and techniques of the agricultural system itself, will cause the spread of that tradition to occur at a rate greater than that of other, more adaptive and stable, agricultural traditions. Hence, not only is agriculture more fit while being less adaptive, but a

positive selection for instability in production will tend to increase the maladaptiveness of agricultural systems over time.

A recent volume, edited by Cohen & Armelagos (1984), presents abundant evidence which indicates that the archaeological record is largely in accord with predictions that may be drawn from the co-evolutionary model for the origins and spread of agriculture. Under the co-evolutionary model, it would be predicted that major population stress would originate with highly developed agricultural systems (the phase of 'agricultural domestication' described in Rindos 1984, pp. 164–72 and his discussion of population pressure (*ibid.*, pp. 205–17). It would be further intensified as agricultural systems developed and spread by means of the positive selection for optimally unstable systems during diffusion episodes.

These predictions stand in stark contrast to those of the two other contemporary schools modelling the origins of agriculture. The first school represents the mainstream of anthropological and archaeological theory. Despite great differences in approach by specific authors, it is unified by an adaptationistic, cultural-ecological perspective. An equilibrium-based analysis of cultural function and change is one of the major assumptions underlying work done by members of this school. I include here such authors as Flannery (1965, 1968, 1973), Binford (1968), Harris (1969, 1972, 1977), Bray (1976, 1977), Reed (1977), and Wright (1977). As Roosevelt (1984, p. 569) points out, an equilibrium-centred view of cultural change has clear implications in terms of stress on humans that might be found in the archaeological record: 'the equilibrium theory predicts that physiological stress should occur only rarely and that cultural adaptation should increasingly buffer people from stress'. Under this mode, the transition to sedentism would be expected to be accompanied by a 'decrease in mortality'. Cultural ecology, with its emphasis upon adaptation and homeostasis, sees cultural change as motivated by human adaptation; *increased adaptiveness* should therefore result from realized cultural changes.

The other contemporary school of thought concerning agricultural origins applies a population-pressure model. This is best exemplified in the work of Cohen (1977), although others such as Smith (1972), Spooner (1972), Grigg (1976), and Abernathy (1979) have advanced similar views. The theory (which I will not criticize here on theoretical grounds) holds that cultural change is the result of human adaptations to their own increasing numbers. Population pressures generated by the slow increase of human populations forces new adaptations to be adopted if humans are simply to 'stay in the same place'; cultural change is the result of the need to *maintain adaptiveness*. Here the predictions for the archaeological record would be 'that physiological stress should be recurrent and persistent, with particularly severe stress possibly occurring during incipient agriculture' (Roosevelt 1984, p. 569).

In Roosevelt's review (1984) of the archaeological indicators of skeletal stress, she was able to make the following generalizations:

Although there is a relative lack of evidence for the Paleolithic stage, enough skeletons have been studied that it seems clear that seasonal and periodic stress regularly affected most prehistoric hunting-gathering populations . . . What also seems clear is that severe and chronic stress . . . is not characteristic of these populations. There is no evidence of frequent, severe malnutrition, so the diet must have been adequate . . .

Stress, however, does not seem to have become common and widespread until after the development of high degrees of sedentism, population density and reliance on intensive agriculture. At this stage in all regions the incidence of physiological stress increases greatly, and average mortality rates increase appreciably . . . Stature in many populations appears to have been considerably lower than would be expected if genetically-determined height maxima had been reached, which suggests that the growth arrests documented by pathologies were causing stunting . . .

It seems that a large proportion of most sedentary populations under intensive agriculture underwent chronic and life-threatening malnutrition and disease, especially during infancy and childhood. The causes of the nutritional stress are likely to have been the poverty of the staple crops in most nutrients except calories, periodic famines caused by the instability of the agricultural system, and chronic lack of food due to both population growth and economic expropriation by elites (Roosevelt 1984, pp. 572-73).

As Roosevelt notes in summary, '[t]he origin of agriculture, then, cannot accurately be attributed to the existence of unusually high levels of [population] pressure at the time.' Furthermore, the increased stress occurring with the appearance of developed agricultural systems contradicts the expectations of the cultural ecologists, whereas the general pattern and the specific timing of the appearance of indicators of greatly heightened stress is completely congruent with the predictions of the co-evolutionary model.

Natural selection and cultural change

The issue of *undirected* variation is critical to the development of a scientific understanding of human cultural evolution. Viewing variation as undirected brings about a change in the way in which we set about attempting to explain cultural evolution. Here, the spread of behaviour throughout a society, or the spread of a particular type of behaviour (rather than another) throughout the species, is the result of the fitness induced by that behaviour (and, again, I am using 'fitness' in a broad sense that includes both demographic and symbolic aspects and goes beyond simple genetic contribution to future generations). Rather than seeing change as a consequence of the adoption of a

particular form of behaviour, emphasis is placed upon the historical *consequences* of a particular variant form of behaviour for the humans exhibiting that behaviour.

The critical issue in this context is whether natural selection is the process responsible for the changes that have occurred over time in human subsistence patterns. The centrality of natural selection in Darwinism arises from its ability to bring about evolution. From the Darwinian perspective, undirected variation is important for its role in fuelling the engine of evolutionary change by generating new forms which may then be subject to selection. Indeed, we may claim confidently that without a true concept of undirected variation, natural selection is not only unnecessary but is actually impossible. Natural selection, within Darwinian theory, is the only directional force in evolution. If variation is less than undirected, then natural selection cannot be seen as a *creative* force in evolution and must perforce maintain its simple, pre-Darwinian role of removing those variant forms that accidentally deviate from the true type of the species (see discussion in Rindos 1984). Only if we see variation as being produced randomly with respect to selective pressures, may we claim that the directionality that may be observed in evolution over time is the result of natural selection.

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3 *Domestication and domiculture in northern Australia: a social perspective*

A. K. CHASE

The concept of domestication has recently been extended by some authors from its orthodox biological definition (cf. Harris Ch. 1, this volume) to embrace wider aspects of the relationships that exist between people and plants. Hynes & Chase (1982) was an attempt to apply such an approach. In it we discussed Australian Aboriginal influence upon plant communities in the Cape York Peninsula of northern Queensland. The main aim of that paper was to query an over-simplistic application of the concept of domestication to the Australian Aboriginal case, and in doing so, to elaborate upon the quite complex relationships that existed between plants and Aboriginal people, with particular reference to a coastal site in the peninsula. These complexities ranged from the way plants are classified, valued, and related to the social world, to the ways they were used by individuals and groups in the seasonal cycle. We emphasized that Australian hunter-gatherers cannot be considered ecologically passive in a supposedly 'natural' landscape simply because they did not engage in a pattern of behaviour usually subsumed under the concept of agriculture. Neither, we argued, can plant-community modification by long-term hunter-gatherer occupation and use be presumed to be the result of 'accidental' or 'unconscious' action. We proposed that the human-plant interaction process has three ecologically related dimensions:

- (a) The cultural and social 'stance' of the human groups toward their particular domain, as expressed in the rules of the society concerning use of plants and other parts of the habitat at particular times. We can refer to this as the rationalization of action (Giddens 1979, p. 215).
- (b) The range of actual plant-exploitation practices as they affect different plant communities at particular times, and the means by which these practices are maintained by a society.
- (c) The dynamic processes involved in changing the morphology, distribution, and genetics of certain species, and, through interaction, changing aspects of the exploiting society.

Summarizing these, we may consider human-plant relationships as time-and-space specific, and involving human social action in a complex environ-

ment: an economic process which involves more than plants in the production system. The point which forms the central contention of this chapter is the essentially *social* nature of human economy; interrelationships among humans are likely to be of a higher order of importance in maintaining social continuity than the relations of particular individuals or groups to any resource base in the environment.

To return briefly to the 1982 paper; at that time we were concerned with disentangling domestication, as an analytical construct, from that of agriculture. Furthermore, we were anxious to free discussion from the still prevalent notions of 'progress' and 'development' which unfortunately remain attached to this area of discourse. We drew attention to certain behaviours which complicate any simplistic division between hunter-gatherers on the one hand and domesticators/agriculturalists on the other. Examples given included replacement planting, the planting of yams in new island environments, the husbanding of fruit trees, etc. (cf. Harris Ch. 1, Yen Ch. 4, this volume). All such behaviours, we argued, need to be viewed against a backdrop of small-group local organization, long-term coastal occupation, and a complex Aboriginal science of speciation, plant behaviour, and extractive technologies. We suggested that the process of plant (and other) resource exploitation needed to be viewed from the perspective of localized social groups intersecting spatially and temporally with particular environments. This intersection results in a series of hearth-based areas of exploitation (domuses), each carrying with it a package of resource locations, restrictions upon open-ended exploitation (religious prohibitions, strategic planning for delayed harvesting, etc.), and localized technologies to fit particular domuses. We suggested the term *domiculture* for these localized packages of interaction between people and resources.

The domain of plants and people

After that paper was published, David Rindos produced his major work on the origins of agriculture (Rindos 1984) addressing the use of the terms agriculture and domestication as analytical constructs. While I find much to disagree with in his Darwinian perspective on the evolution of agriculture (1984, & Ch. 2, this volume), and with his use of the somewhat nebulous notion of culture traits, he has dealt firmly with the problem of unshackling domestication from the conventional role ascribed to it as the necessary prime-mover and precursor of agriculture (cf. Harris Ch. 1, this volume). But, at the same time, he perpetuated the myth that Australian hunter-gatherer systems of resource exploitation are 'simple' (Rindos 1984, p. 162). One can well ask in what terms such simplicity exists. In the cultural views of the society? In the technologies of exploitation employed? In the social organization of groups appropriating resources from the environment, and in the patterns of distribution resulting from the organized use of human labour? The point here is that categorizing hunter-gatherer beliefs and/or

actions as simple – or, indeed, seeing hunter–gatherers as ‘incidental’ domesticators (Rindos 1984, pp. 154–8) – begs the central issue. This issue is the importance of human sociality in the production and distribution process. When we talk of economic processes – as surely we must when we discuss plant and other natural-resource use – we are dealing essentially with processes which are socially initiated, articulated, and maintained. Furthermore these are processes which are used to perpetuate social goals over and above simple biological survival of the individual actors in a given environment.

This is, of course, a matter well recognized by economists and anthropologists of many theoretical hues and which has been most productively explored by analysts who have taken Marxist ideas as their inspiration (e.g. Sahlin 1972, Friedman 1975, Godelier 1977, Ingold 1980, Meillassoux 1981). Terms such as modes and means of production, despite some overuse, do have the advantage of recognizing the importance of social processes in the interaction of human groups with their environments in resource exploitation. In this chapter my purpose is to approach the issue of domestication and agriculture from the social and cultural side of the coin, rather than from that of the natural world of plants and animals, and in order to do so it is necessary to introduce some social theory.

Giddens has produced a large and complex synthesis of ideas in his general theory of society and social change (Giddens 1979, 1984). I shall do inadequate justice to his work by summarizing some of the ideas which I see as having relevance to those issues of social change which are ultimately involved in any discussion of the origins of agriculture. His basic thesis is that any analysis of societies and of what they do should involve the concept of social actors as knowledgeable agents who rationalize their actions in routine daily life as members of social groups. Social action takes place at particular contextual intersections of time and space. Social change involves both of these dimensions. In this sense, according to Giddens, historical and geographical concepts (and, I would add, human ecological ones as well) are synthetically involved in social analysis – perhaps best expressed through the concept of regionalization (Giddens 1984).

Importantly, although humans must be seen as knowledgeable agents in routinized activities (which keep reproducing the social collectivity) there can be unintended consequences of action which can lead to transformational change; a ‘traditional’ society is small and isolated, with tradition dominating as the normative base for the rules of routinized daily life. Such societies are ‘cold’ in that they exhibit strong closure in respect of traditional rules of behaviour, action in time and space, and future reproduction of social structure (rules and resources drawn upon in daily life to sustain the systemic patterning of social relations across time and space). Tradition, as it were, underwrites the continuity of practices, which in turn reflexively organize the future structure (Giddens 1979, p. 220). In such societies deroutinization of practices, as Giddens refers to it – and we must assume this happens in a shift to agricultural practices – is not an easy matter.