Forest, field, pasture, moor, hedgerow, garden, plantation, and bog—all are landscape elements partially defined on the basis of the plants growing there; all have a specific set of environmental, ecological, and structural characteristics; all have a color, texture, and shape; all are living and changing elements of the material world in which human experience is situated; all dominate the visible form of land on which they are found; and several (for example, plantation, forest, garden, field, pasture) carry specific economic, social, and political meanings, depending on historical and geographical context. Like it or not, plants are key landscape elements, being directly, or through the land on which they grow, valuable, useful, negotiable, and politically active economic and social resources. Plants also may carry symbolic as well as use values, (for example, the four-leaf clover as a sign of good luck); sometimes plants even stand as symbols of cosmology or identity, appearing as actors in creation beliefs (for instance, the Grass Seed Dreaming of Aboriginal peoples in central Australia; cf. David 2002: 63) and being used in the construction of group identity (for example, the Scottish thistle; the Irish shamrock; the Australian waratah).

Among the most useful archaeological sources for directly investigating the complex web of relationships involving plants and people are seeds (see “Material and Method,” below). Seeds are commonly used for numerous purposes (for example, food, oils, drugs), widely preserved in many archaeological contexts, and are also identifiable to a high level of specificity. Seed analysis has been vital for understanding past diet, economy, and the origins of agriculture (e.g., Hillman 2000; Weiss, Kislev, and Hartmann 2006; Wetterstrom 1986) but has played a less important role than it should in landscape archaeology. This, in part, reflects the narrow theoretical base that analysts often bring to their work (see Thomas 1990) and also the perception of “science-based” archaeology in the broader archaeological world. Here I use examples from several geographical regions, but especially southwest Asia, to review how the analysis of seeds from archaeological sites has been used in landscape archaeology and why it could make a more substantial contribution than it usually does. This discussion is followed by a brief introductory guide to the methods of seed analysis, which focuses on the analysis of seeds from archaeological contexts, rather than from natural sediments.

Theory, Practice, and the Construction of Archaeobotanical Knowledge

Seeds are directly studied within the subdiscipline of archaeobotany (here considered synonymous...
Chapter 43: Beyond Economy: Seed Analysis in Landscape Archaeology

with palaeoethnobotany), which generally continues to interpret the human career in the functionalist adaptive terms of cultural evolution. Key research themes mostly reflect that theoretical stance and include subsistence (that is, the quest for food and other essential items); environmental adaptation; and economic change (especially relating to agricultural and technical innovation). Archaeobotany’s approach to landscape archaeology has been largely framed within these terms, describing the environment and the resources it contains, then mapping people onto it through the identification of activities represented in the seeds, fruits, charcoalcs, and other botanical remains found on archaeological sites. Location of gathering/production activities can be identified through the environmental preferences of the plants involved, with reference to reconstruction of the local environment and modern analogues. Production, processing, and consumption activities are identified with reference to ethnographic observations of plant use, in the tradition of “middle range” research. Archaeobotany also follows its own ethnobotanical and ecological interests that have a bearing on landscape, such as the development of agricultural techniques and human modification of environments. The subject has developed a powerful set of tools and in less than 30 years has gone from a marginal interest to a central, high profile part of archaeological enquiry that has huge time depth (e.g., Goren-Inbar et al. 2004) and is involved in several key debates about the origins and historical trajectories of the human condition (see also Bar-Yosef, Terrell and Hart, both this volume).

Plant-based activities, including agriculture, gathering, and forestry, are major human engagements with the nonhuman material world, requiring social cooperation for their success, and are part of the suite of activities through which people experience and create their world. Archaeobotany has usually assumed that material needs drive human engagement with the nonhuman world and that the logical need for resources determines social strategies for their acquisition. In the standard logic of evolutionary cultural ecology, resources to fulfill material needs are determined by the environment so that society ultimately reflects adaptation to the environment via the economy, which is the means of producing, extracting, distributing, and consuming these resources. It is generally assumed that economic exploitation of plants is practiced optimally and that there is little explicit discussion within the subject of how knowledge about plants and places was achieved or created in the utility and the distribution of plants by past populations is assumed. Many archaeobotanical treatments, though not all, continue to follow this theoretical approach, which, in the positivist tradition, denies the relevance of social, ideological, and cultural phenomena for understanding human affairs and assumes that economic and social phenomena can be analyzed in isolation from each other.

Although cultural ecology often underpins conceptions of human-plant relationships, detailed knowledge of which plants were used and what they were used for relies on the application to seed data of “real-world” knowledge drawn from ethnographic, experimental, and ecological studies. Such applications of seed data can range from use of ecological tolerances of a species to understand past environments, to complex predictive models that seek to identify human behaviors via compositional analysis of their material traces. Such models, a product of middle range theory (see Charles and Halstead 2001), have been particularly useful in understanding crop processing and husbandry practices as manifest in seed remains (e.g., Bogaard 2004; Hillman 1984).

Archaeobotanical knowledge is thus largely created and articulated in a particular way, which is not only difficult for nonspecialists to understand but also has explored only some of the interpretative potential plant-centered studies offer for understanding past human experience. Furthermore, because archaeology as a whole, and landscape archaeology in particular, have moved beyond cultural ecology and middle range theory, the themes studied in many seed analyses are themselves of marginal concern to current debates. This lack of engagement with contemporary theory and focus on archaeobotanical interests have led to a cursory treatment of plants and vegetation in many archaeologies of landscape, a trend exacerbated by the marginalization of “science-based” archaeology by postprocessual polemic. This is unfortunate, because, as I have attempted to articulate above, plants are key and ever-changing components of landscape, and knowledge about them is essential for understanding both the landscape’s changing material form over time, even if used as simply a backdrop for human agents, and its role in the social creation of the human world. Exclusion to a scientific margin denies landscape archaeology the full use of the important information archaeobotany already provides about human actions and the largely untapped social, visual, structural, and ideological properties of plants and vegetation. Full exploitation of this information requires a
be of great use in identifying activities related to the production, procurement, processing, and consumption of plant resources. For example, crop-processing stage (that is, a particular step in the removal of edible grain from inedible chaff) is routinely identified in Old World archaeobotany via quantitative comparison to ethnographic models of plant use (e.g., Bogaard 2004). Largely, this has been done to identify the selective effects of crop processing on crop weed seed presence, a key means of identifying the detail of agricultural techniques used, such as sowing, ploughing, and manuring, which are important for understanding how crops were grown and the spread of production systems (see Bogaard 2004). Effective means of identifying processing techniques have also been formulated for gathered plants (e.g., Head, Atchison, and Fullagar 2002). Other studies have used similar data to reconstruct patterns of regional trade and exchange (e.g., Weiss and Kislev 2003).

We can make an interpretative leap from landscape mapping and identifying plant-based activities to understanding where encounters with plants took place in the past. Plants grow in particular spots in the landscape with particular environmental characteristics, identifiable via the tolerances of the plant found in archaeological assemblages. For example, weed seeds found with crop seed provide information about where in the landscape fields were situated, based on the soil preference of those weedy plants. Thus, seed analysis provides a means of sensing human encounters with place and thus the creation of the world through lived experience. The spatial detail of place that seed analysis can bring depends largely on the floral structure of the landscape and the environmental specificity of the preserved plants; it would be impossible to spatially differentiate the site of an encounter in a landscape covered by a single vegetation type, but it would be possible where steep environmental gradients caused changes in the composition and structure of vegetation. For example, the landscape of Neolithic Çatalhöyük in Turkey was one of sharply defined environmental gradients from the immediate landscape of lake and wetland to the more distant calcareous arid steppe to distant well-watered hills (Fairbairn, Atchison, and Fullagar 2005). The presence of hackberry seeds in rubbish dumps at the site, a plant of the hill zone providing edible fruits, immediately indicates movement to, from, and within that area; wetland plant seeds in sheep/goat dung indicate gathering of fodder or grazing on the wetland closer to the site.

We can thus use a contextual seed analysis to identify seasonalities, as well as the people involved in the activities. This approach can also locate the activities in time as well as place, and inform on who were using the lands in question. We can thus locate the activities of the past in time and space, a key aspect of understanding the past in its original context.
places where particular activities were carried out or, to use Ingold's term, a taskscape (Ingold 1993). Agricultural techniques, such as harvesting and threshing, take place somewhere in the landscape—harvesting takes place in the crop field; threshing may take place there or in a village threshing ground; removing the last seeds before preparing a meal may take place in the home. Also, the identification of a particular activity usually implies others—harvesting in the field and threshing in the village implies that the crops were transported from one place to another. At Çatalhöyük, the evidence suggests a particularly complex construction and use of the landscape for many kilometers around the site, including crop production, which may have included management of fields at great distance from the site itself (Fairbairn 2005a).

This study challenged the optimizing assumptions inherent in interpretations of agriculture informed by cultural ecology and instead provided a culturally specific and historically grounded interpretation of praxis. Archaeological analysis in Australia has also suggested that gathering fruits may be as much about seeing country as about gathering food (Head, Atchison, and Fullagar 2002), while a restraint on seed grinding was at times as much about the way the seed grinder felt about seed grinding as it was about food production (David 2002: chapter 8).

Landscapes also have visual and structural qualities that vary with conditions, such as the weather, and also with the life and growth cycles of plants. Plants, especially trees, are important structural elements of the inhabited world and could be considered to define places in a similar way to stone monuments (e.g., Barrett 1996). Plants have greatly differing growth forms that vary with the vegetation of which they are part, because trees growing in an open field will be more compact than the specimens growing in closed woodland, which tend to be taller and more open in structure. They also vary in color and openness, depending partly on the season in temperate zones, where autumn brings a loss of leaves and an opening of vegetation. Traditionally, archaeobotany ignores these properties, but that does not mean they can't be established from seed lists and may perhaps add additional elements to phenomenological interpretations (see Tilley this volume).

**Sociality and Social Order**

An understanding of plants and plant-based activities is relevant to understanding the sociality of landscape for human agents and landscape as an additional element in the negotiation of social order. As a landscape for human agents and landscape as an environment, landscapes are a social process allowed that to happen. Finding, growing, producing, processing, and using plants requires also decisions to be made about which activities should be carried out, the location of these tasks, the timing of events, and the organization of people (that is, labor) to ensure that they are completed satisfactorily. Many plant-based tasks require the cooperation of more than one person in their practical application or in obtaining permission to carry them out. They are, therefore, social as well as economic activities subject to the disagreement, political negotiation and unintended consequences that accompany just about any decision involving land, resources, and people in any society.

The social power of plant foods has been widely explored (e.g., Hastorf 1991); less attention has been given to understanding this aspect of plants and plant use in the landscape. At Çatalhöyük, tasks identified from seed analyses were not uniformly distributed evenly across wetland and dryland landscapes; parts of the landscape came in and out of social focus depending on the time of year and type of activity—large groups in the distant hill zone focused on fields during harvest and perhaps dispersed in the surrounding woodland when collecting fruits; a greater intensity of social engagement within houses focused on preparing seed stores before winter (Fairbairn, Near, and Martinoli 2005). At the same site, intense social collaboration, including crop production and distribution, and a strong sense of group identity, manifest in part on the basis of landownership, may have supported an "inefficient" production system that produced internal tensions leading to collapse of the system when arable land availability increased owing to environmental change (Fairbairn 2005a).

**Time and Memory**

If landscape is time materializing (Bender 2002), plants provide some of the key material signs by which time is experienced and understood. In seasonal climates, plants have cyclical growth patterns: spring with its flush of new greenery, autumn with its fruit and leaf-fall and winter with its bare branches. In tropical climates, change may be much more subtle and less predictable,
nonetheless and may be an important means of conceptualizing time. Seasonal change has mainly appeared in archaeobotanical landscape readings with regard to understanding resource schedules, which detail the resources available, or actually used as shown in archaeological studies, in parts of the landscape throughout the year. Schedules are important tools for understanding some of the limits of human action within seasonal landscapes, though they are often used prescriptively and assume that people have the knowledge to use an environment optimally. They can, however, be used to understand how different people experienced different parts of the landscape at different times of the year. For example, at Neolithic Çatalhöyük, the distant hills became key places during the harvest season for active adults but may have been contained to memory during the winter and spring, when other activities nearer the houses were more pressing and access was more difficult (Fairbairn et al. 2006). For the very old or disabled, some distant places may have become excluded from direct experience and kept alive only in the memory. Usually, long-term, extra-annual patterns of vegetation change have been constructed to understand patterns of changing resources and have been important for understanding the origins of agriculture in Asia (e.g., Hillman 1996). The patterns of plant growth so created may have been experienced and understood in a number of ways and could be interpreted accordingly. Evidence of famine, crop failure, and environmental catastrophe, as in archaeological and other evidence of economic, social, and landscape change, caused by large-scale changes in weather or human agency could be read in terms of plenty, despair, and recovery (see Evans 2003) as manifest in landscapes of plenty, despair, and recovery.

**Landscape Creation and Domestication**

Seed analysis is a key means of understanding the human modification and creation of landscapes through selecting, removing, planting, and transplanting plants growing there, in association with burning and effects of grazing livestock. Human modification of vegetation dates from at least the Late Pleistocene and was well advanced in many regions by the mid-Holocene, being most closely associated with agriculture and the development of Classical civilizations. At one extreme, humans formally domesticated some plant species—that is, crops—by establishing control over reproduction, selection, and dispersal mechanisms, and for identifying those processes (see Denham et al. 2003; Fuller et al. 2004; Kislev, Hartmann, and Bar-Yosef 2006; papers in Colledge and Conolly 2007; Weiss, Kislev, and Hartmann 2006; Zohary and Hopf 2000). Human-modified, domesticated landscapes also developed in most regions of the world in the distant past, and their identification through archaeobotany provides perhaps the only way of investigating plant domestication in some tropical areas (Fairbairn 2005b; Terrell et al. 2003).

**Material and Method**

The following section provides a very brief and general overview of some key methods and materials for archaeological seed analysis. For more details consult the cited texts, especially Pearsall (2000), and other published seed analyses in the journals detailed below.

**What Are Seeds?**

In archaeobotany, *seed* is a convenient shorthand term that includes the following plant structures (which I here define in their strict botanical sense):

1. Fruits—found only in flowering plants (Angiosperms), developed from the plant ovary and include nutshells (for example, hazelnut, or *Canarium*, nutshells) and legume pods, but may also be fused to the seed, as in the case of grass grains (caryopses). Seeds in the strict sense develop within these fruiting structures and may be ejected from the fruit when dispersed (for instance, in legumes) or dispersed attached to fruiting structures (for example, cereal grains, plum or *Canarium* seeds dispersed within their stones or endocarps).

2. Seeds—developed from the ovule, the product of sexual reproduction in the conifers (Gymnosperms) and flowering plants (Angiosperms), consisting of an embryonic plant, and in many cases storage tissue, held within a protective coat (testa); legumes produce seeds (for example, a pea) within pods (the fruits); Bunya pine (a conifer) nuts, are, in fact, seeds, since they contain no ovarian tissue; *Pandanus* keys, *Canarium* nuts, and hazelnuts all consist of a hard shell (the fruit) containing seeds within (the fruit) containing seeds within (the keys, the fruit) containing seeds within (the kernels).
Seed analysis also usually includes the analysis of chaff, which consists of the leaflike structures (glumes, rachis fragments, lemmas, awns) found in the cereals and other grasses that protect the grain and is removed by processing techniques before the grain is eaten.

*Seed* is thus a useful way of referring to the many plant parts associated with production and dispersal of new plants by sexual reproduction. It cuts across the confusing mix of such scientific and common English definitions of terms as seeds, nuts, and fruits. Seeds are diverse in shape and size and are produced to disperse and to protect embryonic plants in their journey from parent to growth site; hence, they are usually compact and robust. Seed production rate varies widely between plant species and depends in part on reproductive strategy: low in plants that successfully propagate by other means (for example, rhizomes) and higher in those short-lived plants, such as many arable weeds, that rely solely on this means of propagation.

**Where and How Are They Preserved?**

Most plant parts decay but are preserved when they (1) are naturally resistant to decay; (2) are deposited in an environment where decay is suppressed (for example, an anaerobic swamp); or (3) are transformed into a state that resists decay (for instance, charring [partial burning] or mineralization [fossilization]). Seeds are naturally robust and have a greater chance than most other plant parts of surviving in archaeological deposits in an identifiable state. As with production and distribution, preservation potential varies between plant species. Some small and fragile seeds, such as those of willow (*Salix* spp.), are rarely, if ever, preserved, whereas the silica rich seeds of the arable weed corn gromwell (*Lithospermum arvense*) are often preserved regardless of preservation conditions. Most seeds are preserved on dry archaeological sites by charring, with anaerobic conditions in wells, ditches, pits, and latrines providing important loci for preservation of waterlogged remains.

**Field Techniques**

Seeds are usually recovered from soil samples collected from archaeological contexts. Sampling strategy and sample size are subjects of some debate and vary with analytical aims and resources (Pearsall 2000; van der Veen and Fieller 1982). Seeds are only systematically recovered from soil samples by sieving, most being far too small to extract from archaeological sediments by hand.

**Laboratory Methods**

Analysis involves separation of the seeds from other preserved materials using low-powered microscopy, usually after sieving into size fractions (for example, > 4 mm, 2–4 mm). Very large samples can be split into subsamples before analysis. Because small subsamples may be unrepresentative of the original sample population, care should be taken when developing subsampling strategies. Experimentation has shown that subsampling is most representative when using a geological sample splitter (also known as a riffle-box), although other methods can be almost as accurate (van der Veen and Fieller 1982).

Seeds are at the sharp-end of evolutionary selection pressures, their form being directly related to a species’ reproductive success. They are thus often highly differentiated in form and are easier to identify to species level than many other plant fossil groups (for example, wood and pollen) and so provide a greater level of detail about environmental conditions and plant community composition. Identification follows uniformitarian principles, relying on comparison of ancient specimens to those from known plant species. Identification is a key analytical step, assigning a plant identity to the fossil type and with it all the characteristics of that plant type. A collection of modern seed reference specimens is vital for accurate identification (see Nesbitt, Colledge, and Murray 2003), though seed manuals are also of great value (e.g., Cappers, Bekker, and Jans 2006; Jacomet 2006; for a good list of older sources see Nesbitt and Greig 1989), especially those with well-designed keys (e.g., Nesbitt 2006). Although some seeds are identifiable with full Linnean species, many can be identified only at a lower level of taxonomic specificity, such as family, subfamily, genus, and type, depending on biological differentiation and preservation. Furthermore, identifications vary in their certainty as reflected in commonly used notation.

Identification uses (1) morphology (that is, seed shape size and form visible under low and high-powered microscopy) and (2) anatomy, (that is, the plant structure, visible using high powered
Identifying Ecology and Activities

Seed analysis uses the known form and environmental characteristics of modern examples of identified species as a basis for identifying past environmental conditions and vegetation composition/structure. Seed assemblage composition is commonly used to identify aspects of crop processing and husbandry practices, as well as the effect of the former on sample composition and comparability (e.g., Bogaard 2004; Hillman 1984). Assemblage taphonomy—that is, the processes affecting the source of fossils and sample composition—are vitally important for understanding the interpretative limits of analytical comparisons made using these analogues (see SEM). Shape and features such as surface cell patterns should be described using standard terminology (e.g., Nesbitt 2006), and shape may also be described using measurements of length, breadth, and thickness, which are especially useful in analysis of plant groups with similar seed forms (for example, grasses, including cereals). Description and preferably illustration of specimens are important to help validate identifications, especially in poorly known regions. High quality photographs using SEM or digital imaging on light microscopes are now routine. Drawings are more time consuming and difficult to produce but are perhaps the best form of visual recording, since they can be drawn to emphasize key diagnostic features.

Quantification allows analysis of patterns in seed data and comparison to quantitative models identifying particular plant-base activities. Seeds are counted, though large fragmented items may be quantified by weight. Fragmentation can be accommodated by (1) generating a minimum number of individuals (MNI), counting only parts that appear once in every seed or (2) dividing the fragment weight by a single seed equivalent, based on seeds preserved in the same way from the same site or region (“thousand grain weight”). Abundance data can be used in exploratory statistical investigations—for example, using correspondence analysis—to look for temporal or spatial trends. Sample data can also be compared to external ethnobotanical and ecological data using discriminant analysis or canonical correspondence analysis, as successfully applied to crop weed data to remove the effects of crop processing on sample composition (see example given by Bogaard 2004). Presence and ubiquity (% presence) data are also commonly generated to look at general trends in plant appearance.

Conclusions

Seeds are widely preserved in archaeological sites, and seed analysis provides a means of empirically investigating the use of plants by ancient people and thus a direct means of sensing ancient landscapes. Methods for recovering, identifying, analyzing, and interpreting seed assemblages are well established using standard scientific principles and with reference to modern ecology and ethno- graphic analogues. Though most interpretation has been framed historically within the positivist traditions of cultural ecology, seed analysis has the potential to provide information suited to landscape archaeology studies informed by a wide range of theoretical positions. Thus the subject should in the future move beyond the narrow confines of palaeoconomy and palaeoecology to address a diverse range of contemporary interests in landscape archaeology.

Resources for Further Study

1. Key general texts

2. Journals
   a. Vegetation History and Archaeobotany
   b. Environmental Archaeology; Journal of Human Palaeoecology
   c. Journal of Archaeological Science
   d. Review of Palaeobotany and Palynology

3. Online databases of archaeological finds and reference collections from the Old World
   a. Literature on archaeological remains of cultivated plants 1981–2004 (www.archeobotany.de/)
   b. Archaeobotanical database of Eastern Mediterranean and Near Eastern sites (www.cuminum.de/archaeobotany/)
   c. Naomi Miller’s database of Near Eastern archaeobotanical publications
d. George Willcox's website for southwest Asia (http://perso.wanadoo.fr/g.willcox/)

e. The digital seed atlas of the Netherlands (www.seedatlas.nl/)

4. Relevant scientific associations

a. International Workgroup in Palaeoethnobotany (IWGP) (www.palaeoethnobotany.com/)
b. Association for Environmental Archaeology (AEA) (www.envarch.net/)
c. Society for Archaeological Sciences (SAS) (www.socarchsci.org/)

References


