Charcoal analysis has traditionally concerned the identification, quantification, and analysis of woody plants present as charcoal in archaeological and other sediments. Charcoal is common in many archaeological sites and represents material remains of human activity. Although a source of dating, charcoal also provides identification of the wood of trees and shrubs utilized as firewood and should be used to give insight into larger questions within archaeology beyond construction of chronologies and the past environment. Some scholars have extended the charcoal analysis to include fragmentation of the charcoal as an additional facet (Dolby In preparation; Hesse and Rosen 1988), while the integration of studies on charcoal taphonomy and the ensuing implications for archaeological and paleoenvironmental studies has proceeded fitfully (see Dolby 1995, In preparation; Prior and Alvin 1983, 1986; Prior and Gasson 1993; Rossen and Olson 1985). This chapter outlines ways in which charcoal analyses have been incorporated into landscape archaeology and suggests new potential approaches. I begin with a brief history and outline of methodologies.

**History of Charcoal Analysis**

Charcoal analysis has been carried out on archaeological charcoal for over a century. Heer and Passerini (Passerini 1864; Heer 1866; Heer and Passerini 1865, all cited in Castelletti 1990; see also Asouti 2006) are widely regarded as pioneers in the field. Charcoal analyses during these early years usually entailed the construction of “shopping lists” of taxa present, with at best a random citation of ethnographic or recent uses of the given taxa. In 1940, Salisbury and Jane (1940) published a paper on the charcoal from Maiden Castle, Dorset (England). Here they argued for Neolithic Oak-Hazel closed woodland that became more open through human exploitation. They further concluded on the basis of charcoal ring widths that past climates during this period of the Neolithic were similar to those of the present day.

This appears to be the earliest charcoal analysis to present details of an assemblage (with relative frequencies of identified taxa) and to seriously extrapolate information on environmental conditions and human activity. Godwin and Tansley published a criticism the following year (1941) that, while praising the “extensive data” presented, argued strongly against the inferences drawn from the Maiden Castle study. They pointed out that the taphonomy of burning and human selection may skew the assemblage away from the living population of trees and argued for more exact quantification of data. These cogent arguments are still being confronted some 65 years later.
Methods

The first step in charcoal analysis is the determination of taxa. Wood has a distinctive arrangement of cells. Softwoods (gymnosperms, conifers) have different cells from hardwoods (angiosperms, broad-leaved trees). Cells and internal features can have distinctive qualitative or quantitative arrangements, allowing wood type to be ascertained (to sometimes specific taxonomic level, sometimes less precise). Further details on these can be gained from wood anatomy books (e.g., Carlquist 2001; Wilson and White 1986; for features used in identification, see Richter et al. 2004; Wheeler, Baas, and Gasson 1989). The arrangement of cells is preserved in carbonization (the combustion of wood in a reducing atmosphere). While water and volatiles are driven off by heat, without sufficient oxygen, the carbon structures of the cellulose and lignin-rich wood cell walls remain, leaving charcoal behind, often all but pure carbon. Some aspects of wood do not tend to preserve during carbonization (for example, color, fragrance, cell inclusions), while the wood structure loses mass and shrinks, making some wood identification quantitative measures imprecise (for some charcoal becomes extremely distorted, fragile, or homogenized during the deposition or sedimentation process, and identification becomes all but impossible. The presence of a good reference collection and of anatomical keys and literature is essential. Nonetheless, identification of charcoal to species level is regularly carried out.

There are two major strategies for sediment sampling in charcoal analysis. The Montpellier school favors sampling a “floor,” collecting scattered charcoal that represents an accumulation of varying fires and that therefore gives an overview of the utilized vegetation taxa during the period of that surface. However, criticism of this approach includes the view that the targeting of individual archaeological features (representing individual past events), and in particular individual fireplaces, allows us to gain greater details on past human behavior than an analysis of broad and therefore more generalized charcoal assemblages. The selection of wood from individual fires is likely to shed greater light on the cultural and technical requirements of the burning activity. Certainly, a fire or fireplace’s use may vary over its life, but the tighter spatial and temporal frame represented by a single hearth may allow greater insight into the past (for further details on such aspects of methodology, see Donoghue 1989; Figueiral 1999; Figueiral and Willcox 1999; Hastorf and Popper 1988; Pearsall 2000; Smart and Hoffman 1988). Thompson (1994) and Neumann (1999) make strong contributions to the methodology of identification, quantification, and interpretation, and Thiebault (2002) has compiled a broad range of charcoal analyses.

Approaches

What follows is a discussion of some of the areas in which charcoal analysis has made or could make a valuable contribution. The reconstruction of past vegetation and human use of the landscape has been widely carried out, but the reconstruction of cultural activities, domestication, and cultural history are areas that remain underdeveloped or unrealized.

Past Vegetation

Charcoal can be used to investigate the past vegetation of a landscape, but there are limitations and caveats. The reconstruction of past vegetation communities via charcoal analysis is limited generally to the woody fl ora. A caveat on reconstruction attempts is that an archaeological assemblage will tend to be biased toward larger trees, and toward
an assemblage representing the range of woody vegetation). The latter point comes about because people tend to select wood from trees that have desirable firewood characteristics, including the production of dead and dry wood (ideally, dead branches still attached to a tree) and good burning properties (including fragrance, heat output, smoky or smoke-free fire, depending on cultural desirability). Certain taxa have these properties more than others.

The skewing of an archaeological charcoal assemblage toward larger trees comes from human selection, from taphonomy, and from analysis. It is more cost effective to gather larger pieces of wood, not twigs but the larger branches that are more available on larger plants; that is, trees are more commonly foraged for firewood than are shrubs, and larger trees rather than smaller trees. Taphonomic bias causing larger sources of wood to dominate the charcoal record is due to the greater biomass of the larger taxa, the increased likelihood of incomplete combustion of larger wood, and the creation of larger sizes of charcoal by larger logs. Laboratory analysis is most easily carried out on larger pieces of charcoal: they are easily picked out and, more important, are easier to section, thus increasing the taxonomic precision achievable. One way around this laboratory bias is to analyze all charcoal present from an excavated assemblage, which is rarely possible with a large assemblage. Another way to reduce this bias is to subsample based on size—that is, by passing the collected charcoal through Endicott-sieves, creating size-classed subsamples. The use of saturation (or accumulation) curves (the graphing of increasing identified taxa against increasing sample size) will help determine the appropriate size of a subsample while further reducing bias.

In the quantification of an assemblage, numeric count (how many pieces) will tend to bias toward smaller taxa, while total taxon weight will reflect contributing-biomass more. Use of both numerical and weight quantification gives a more accurate picture. The resulting fragmentation analysis can also address issues of differential taxonomic or spatial representation at a given period of time, as well as provide indications of temporal changes in charcoal sequences.

**Human Use of the Landscape**

Charcoal analysis is not only concerned with the environments in which people lived but attempts also to determine patterns of land-use by people in the past. Neumann and associates (1998) carried out an intensive examination of the charcoal the current vegetation surrounding the site. From this, they were able to demonstrate the preferred exploitation for firewood of neighboring dune woodlands and river gallery forests over the more abundant park savanna. However, it is worth remembering that although environments of the recent past are able to be recreated from the present habitats of plants, environments and communities of the more distant past may not have present analogues. The discussion between Willis and colleagues (2000, 2001) and Carcaillet and Vernet (2001) on the presence, identification, and nature of forests in Glacial Maximum Europe is indicative of some of the complexities of pre-Holocene vegetation reconstructions.

**Cultural Activities**

Assemblages of charcoal give information not only on the natural environment but also on the cultural landscape. The use of certain woods for certain purposes allows an understanding of the social differentiation of the place into a culturally conceptualized landscape. For example, the identification of charcoal used in the historic past for high status ceremonies allowed Kolb and Murakami (1994) to identify ritual fireplaces in an Hawai’ian complex. The ceremonial use of pine trees in ancient Lowland Mayan communities and the recognition of places of ceremony and residences of high status is revealed in the work of Lentz, Morehart, and their colleagues (Lentz et al. 2005; Morehart, Lentz, and Prufer 2005).

**Domestication**

In the northwest of the Mediterranean region, Terral (1996, 1997a, 1997b, 2000; Terral and Arnold-Simard 1996; Terral and Durand 2005) has demonstrated an ability to differentiate between wild and cultivated olive wood, the latter’s introduction to the area, and the use of irrigation practices; similar research may be possible with other taxa and in other regions. The importance of arboriculture in the prehistory of western Asia, Southeast Asia, and in the Pacific region has long been a focus of research; the question remains as to whether or not charcoal studies will eventually prove useful to these regional research projects?

**Culture History**

Of course, charcoal—or rather the firewood culture evident from the charcoal assemblage—may give indications of the histories of specific cultural practices and the changing practices of the people in a place.
occupants of a point or space within a landscape. Examples of this could include change in available wood types, the avoidance or use of certain taxa, and the changing needs of fuel for fires—all of these might become apparent in archaeological charcoal assemblages. To date, charcoal analysis has been poorly employed in the elucidation of such questions anywhere in the world. Intersite comparisons and interpretations, or the analysis of complementary sets of assemblages from past communities or regions, have simply not been undertaken (although some of the researchers cited above have now begun such research programs). The work by Lowell (1999) on Mogollon (or prehistoric western Pueblo) fireplaces alerts us to changes in the conceptualization and use of fire and fireplaces in social practice. That social notions and values of fire and “hearth” (along with fire) replaces in social practice. That social

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Conclusions
Charcoal analysis has proved to be a strong tool for investigating the past vegetation around archaeological sites and for helping to reconstruct people’s use of resources within the landscape. It has, however, greater potential than this and more to offer than the listing of woods that have ended up burnt in archaeological deposits. Aspects of culture history may be revealed by charcoal analysis, as illustrated by some of the approaches used to examine cultural activities surrounding fire, wood use, and domestication, all of which are tied to locations within the landscape. Analysis of archaeological charcoal has the potential to inform us about technology, economy, cultural, and social activities and how they vary across space, thus shedding greater light on the people and landscapes in the past.

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