Environmental archaeology is concerned with "the physical and biological elements and relationships that impinge on" the activities of people in the past (Dincauze 2000: xxiv). Although definitions vary, environmental archaeologists consider human activities in the past within their environmental contexts and apply techniques and interpretations derived from the biological and geophysical sciences to archaeological problems. Thus the term "environmental archaeology" encapsulates geoarchaeology, which is concerned with the "application of concepts and methods of the geosciences to archaeological research" (Waters 1992: 3).

Other chapters in this Handbook address specifically how specialist biological knowledge is used in landscape archaeology (e.g., see chapters by Dolby; Fairbairn; Mainland; Matisoo-Smith; Pate; Porch; Rowe and Kershaw). In this chapter, the geoarchaeological aspect of environmental archaeology is characterized, and its relevance to landscape archaeology explored. Sections address key issues associated with the practice of environmental archaeology, namely multidisciplinary teamwork, geoarchaeological investigations of site stratigraphy, scalar problems, and complementarity of techniques. Each issue is illustrated using examples drawn from my own research in the Upper Wahgi valley in the highlands of Papua New Guinea.

Conceptualizing Human-Environment Interactions

Before characterizing the techniques and methods applied by environmental archaeologists, I consider the concepts used to frame and interpret people-environment relations. Often the technical aspects of environmental archaeology have been prioritized over the conceptual. Indeed, and like other branches of archaeological science, technique and method can become ends-in-themselves rather than means-to-an-end, which, in this case is to shed light on people living in the past. Furthermore, a focus on method can be accompanied by a circumscribed critical stance toward the interpretation of results (Dincauze 2000).

Concept and method are interdependent. Concepts provide a framework within which environmental archaeological issues can be addressed; similarly, the results and scope of investigation afforded by the application of innovative techniques can expand and inform conceptual frameworks. Difficulties encountered when seeking to unravel social-environmental interactions in the past can, in part, arise from the ways in which these interactions are conceptualized.

A tendency in archaeology and other disciplines has been to dissemble the human and the environmental as separate spheres, or entities, of
Chapter 46: Interpreting Practices-in-the-Landscape through Geoarchaeology

The landscape represents a “human-scale” of lived-in places. People live in landscapes, whether they are urban, suburban, rural, coastal, and so on; landscapes are a fundamental realm of lived-in-a-past-landscape. How do we begin to access that past? One starting point particularly relevant to environmental archaeologists seeking to unravel the complexities of people living-in-the-landscape is the concept of “practice” (Barrett 1994). The archaeological record provides evidence of past practices, whether the practices were the result of enacted structural influences, dispositions, or individual improvisation (after Bourdieu 1990). Practices are effectively what people do. They constitute the nexus of human-environmental interactions; practices are inscribed in the landscape, thereby providing the visible evidence of past interactions (Figure 46.1).

If practices are taken as a focus, four overlapping and pervasive themes of environmental archaeology emerge:

1. reconstructing human-environmental interactions in the past as manifest through practice;
2. placing past practices within broader social and environmental contexts, for example, attempting to understand why people engaged in certain practices;
3. taking into account the social forms and environmental processes that influence our ability to construct knowledge of past practices, such as issues of site formation processes, taphonomy, preservation, and destruction (Binford 1981; Brain 1981; Mountain and Bowdery 1999; Schiffer 1987);
4. reflecting on the ways in which we come to know the past, effectively comparable to Bourdieu’s (1990) theory of practical knowledge.

The Multidisciplinary Scope of Environmental Archaeology

A multiplicity of approaches and techniques derived from the biological and geophysical sciences are potentially available in the pursuit of a particular problem (see Tables 46.1 and 46.2; also reviews in Dincauze 2000 and Evans and O’Connor 1999). Despite this potential range of techniques, archaeological projects are usually conducted under fiscal constraints and tight schedules. Therefore, the methods, disciplines, and specialists with the greatest potential to address the project aims need to be identified and informed of the relevant financial, scheduling, and other logistical constraints at an early stage of planning.

Practices-in-the-Landscape

The landscape represents a “human-scale” of lived-in places. People live in landscapes, whether they are urban, suburban, rural, coastal, and so on; landscapes are a fundamental realm of lived-environmental possibilism, probabilism, and determinism (see review in Lewthwaite 1966), whereby human activities are freely chosen, environmentally influenced, and determined by the environment, respectively. The systemic approach is more recent and characteristic of cultural ecology, human ecology, and processualism, whereby human and environmental components are conceived as part of one interrelated system (Binford 1965; Clarke 1973), although there is still much debate about the degrees to which social systems are influenced or determined by the environment (e.g., Binford 1965, 1967). These types of approaches have predominated within environmental archaeology (see Dincauze 2000), although there has been some movement toward more socially informed perspectives (Evans 2003).

In recent years, alternative perspectives focusing on people living-in-the-world have emerged within archaeology. Here, the world is not considered in terms of its empirical reality but as a meaningful realm of human activity. Advocates of these perspectives acknowledge, as well as sometimes abuse, the engagement and the creativity of the archaeologist in portraying people living-in-a-past (Tilley 1994; cf. Fleming 1999). These phenomenologically informed conceptions have had limited adoption by environmental archaeologists.

Environmental archaeology can, in principle, serve as a bridge between human activities and environmental processes in the past. Although the techniques of the subdiscipline are predominantly derived from the biological and geophysical sciences, interpretations need not become trapped by a naïve empiricism or neofunctional, mechanistic, and systemic thinking. Rather, environmental archaeology has great potential to contribute to our understanding of the complex, mutually transformative, and recursive nature of human-environment interactions in the past.

study. Subsequently, either the degrees to which people’s activities and way of life are enabled or constrained by the biological and physical environment are assessed (characteristic of culture historic approaches), or human-environment interactions are conceptualized in systemic terms (characteristic of New Archaeology). The former approach echoes early-to-mid-20th century concerns of environmental possibilism, probabilism, and determinism (see review in Lewthwaite 1966), whereby human activities are freely chosen, environmentally influenced, and determined by the environment, respectively. The systemic approach is more recent and characteristic of cultural ecology, human ecology, and processualism, whereby human and environmental components are conceived as part of one interrelated system (Binford 1965; Clarke 1973), although there is still much debate about the degrees to which social systems are influenced or determined by the environment (e.g., Binford 1965, 1967). These types of approaches have predominated within environmental archaeology (see Dincauze 2000), although there has been some movement toward more socially informed perspectives (Evans 2003).
ask are these: “What questions or purpose is the project designed to address?” and “Which methods and techniques are most relevant to the investigation of this particular problem?”

**Teamwork**

Environmental archaeology is increasingly conducted in a multidisciplinary environment. Most environmental archaeologists are specialized in the application of a particular field of the biological or earth sciences to archaeological concerns. Just as archaeologists in other fields of archaeology, they draw on a range of specialists to augment their work and increasingly have to learn how to manage multidisciplinary teams. There are continual problems in trying to get collaborators to think outside their discipline, to get them to understand the goals of the overall project and their role in it, to refashion the meaning of their work and channel it to different aims (without denigrating the work or the aims), to provide results in a timely fashion, and so on. These are not incidental concerns, since they continually undermine projects and the production of results in a timely fashion, but yet they are rarely discussed constructively or taught.

**Geoarchaeology and Site Stratigraphy**

Numerous techniques are employed by geoarchaeologists to reveal information about past environments and how people may be implicated in their below a broad range of such techniques, identifying in particular the kinds of information that they are able to address. Geoarchaeological investigations can focus on the stratigraphy either at a single site or compare results from multiple sites across a landscape. Geoarchaeological analyses are used by archaeologists for a multitude of reasons, the most common being these:

1. To disentangle site formation processes, thereby enabling the reconstruction of depositional (sedimentary) and pedogenic (soil formation) processes through time, with particular reference to archaeological evidence of past practices and differentiating postformation and postburial transformations. Distinct stages in the development of each stratigraphic unit and archaeological context are differentiated: (a) original deposition represented by inherited sedimentary stratification; (b) pedogenic alteration of the sediment and, potentially, the formation of archaeologically significant palaeosols and deposits; (c) pedogenic transformations of contexts prior to and after burial (after Barham 1995: 161).

2. To identify direct and indirect evidence of past practices, most often those associated with agriculture, pastoralism, and occupation.

3. To determine postdepositional modifications and context reliability for subsequent
Table 46.1  Overview of geophysical sciences utilized by environmental archaeologists (that is, geoarchaeology). Note: major overviews generally integrate geology and geomorphology.

<table>
<thead>
<tr>
<th>Science</th>
<th>Environmental Archaeological Significance</th>
<th>Key References</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Climatology</strong></td>
<td>Understanding the influence of past climates (palaeoclimates) and climate change on past environments (palaeoenvironments) and human practices, especially with respect to biotic distributions, glacial cycles, and sea level change; there is an awareness of the cumulative human influences on local, regional, and global climates during the Holocene to the present.</td>
<td>Lamb 1995; Burroughs 2005</td>
</tr>
<tr>
<td><strong>Geochemistry</strong></td>
<td>Applying geochemical techniques (elemental, crystalline, structural, stable, isotopic, palaeomagnetic, and so on) to understand biological, geophysical, and human interrelationships.</td>
<td>Thompson and Oldfield 1986; Sparks 1995; Pollard and Heron 1996</td>
</tr>
<tr>
<td><strong>Geochronology</strong></td>
<td>Applying dating techniques to generate a chronology for archaeological materials, environmental proxies, and associated stratigraphy; the selection of dating technique is dependent on the material being dated and anticipated age range.</td>
<td>Walker 2003</td>
</tr>
<tr>
<td><strong>Geology</strong></td>
<td>Understanding the influence of tectonic and volcanic processes and products on landscape formation and human practice.</td>
<td>Brown 1997; Rapp and Hill 1998; Williams et al. 1998; Garrison 2003; Goldberg and MacPhail 2006</td>
</tr>
<tr>
<td><strong>Geomorphology</strong></td>
<td>Understanding the influence of earth surface processes and products on human practice, often within specific environments such as alluvial, arid, coastal, estuarine, glacial, lacustrine, and marine; there is an awareness of the increasing human influences on geomorphological processes from the late Pleistocene to the present.</td>
<td></td>
</tr>
<tr>
<td><strong>Pedology</strong></td>
<td>Formation of soils on stable substrates (whether of biogenic, geological, or sedimentary origin); significance for understanding past soils (palaeosols), human practices associated with palaeosols (such as cultivation), and the effects of pedogenesis on the alteration, disturbance, and preservation of buried archaeological and palaeoecological remains (namely, site formation processes and taphonomy).</td>
<td>Limbrey 1975; Courty et al. 1989; Barham and MacPhail 1995</td>
</tr>
</tbody>
</table>
Table 46.2 Overview of biological sciences utilized by environmental archaeologists. Note: in several tropical regions archaeobotanists are more reliant on microfossils, especially phytoliths (Piperno 2006) and starch grains (Torrence and Barton 2005) than on traditional macrobotanical identifications of seeds and wood (see Fairbairn, this volume).

<table>
<thead>
<tr>
<th>Science</th>
<th>Subdivision (with Commonly Used Examples)</th>
<th>Environmental Archaeological Significance</th>
<th>Key References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biological anthropology</td>
<td>Macrofossil: bones, teeth, collagen, soft tissues</td>
<td>Examining human remains and past diet, disease, and populations (palaeodiet, palaeopathology, palaeodemography) with reference to lifestyle (and associated practices) and environment</td>
<td>Cohen and Armelagos 1984; Hoppa and Vaupel 2002; Roberts and Manchester 2005</td>
</tr>
<tr>
<td></td>
<td>Microfossil: blood, cellular, and subcellular analyses (biochemistry, isotopes, DNA)</td>
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<td></td>
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<tr>
<td>Botany</td>
<td>Macrofossil: (macrobotanical): seeds, wood, kernels, plant parts, and fibres</td>
<td>Analyzing plant remains to reconstruct vegetation histories (palaeoecology) and to understand people's exploitation of plants (archaeobotany)</td>
<td>Dimbleby 1985; Bennett and Willis 2001; Pearseall 2000</td>
</tr>
<tr>
<td></td>
<td>Microfossil: pollen, phytoliths, starch grains, diatoms, parenchyma</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zoology</td>
<td>Macrofossil: bones, teeth, shells, soft tissues</td>
<td>Analyzing animal remains to reconstruct past environments and to understand people's exploitation of animals (zooarchaeology)</td>
<td>Reitz and Wing 1996; Maltby 2006</td>
</tr>
<tr>
<td></td>
<td>Microfossil: blood, bones, insects, shells, tissue fragments, and residues</td>
<td></td>
<td></td>
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<tr>
<td>Genetics</td>
<td>DNA</td>
<td>Analyzing the genetic traits of contemporary populations (for phylogenies, significant genetic loci) or ancient biological material (for genetic fingerprinting, phylogenies, comparisons with modern populations)</td>
<td>Jones 2001; Gugerli et al. 2005; Willerslev and Cooper 2005</td>
</tr>
<tr>
<td></td>
<td>aDNA (ancient DNA)</td>
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</table>

Geoarchaeological and sedimentological techniques are often differentiated into two groups; those undertaken on disturbed samples and those on undisturbed samples (Canti 1995: 183–6; Courty, Goldberg, and MacPhai 1989: 40–3; Hodgson 1978: 125–32). Disturbed, disaggregated, or bulk samples are used for chemical and physical compositional analyses (for example, elemental, magnetic, mineral, and particle size analyses), whereas undisturbed samples are used for meso- and micromorphological investigations (for example, X-radiograph and thin section analyses). Geoarchaeologists and sedimentologists are often differentiated into two groups; those undertaken on disturbed samples and those on undisturbed samples (Canti 1995: 183–6; Courty, Goldberg, and MacPhai 1989: 40–3; Hodgson 1978: 125–32). Disturbed, disaggregated, or bulk samples are used for chemical and physical compositional analyses (for example, elemental, magnetic, mineral, and particle size analyses), whereas undisturbed samples are used for meso- and micromorphological investigations (for example, X-radiograph and thin section analyses).

**Disturbed Samples: Multitechnique Assessments**

“The exact chemical conditions under which soil minerals form are not known at present” (Bohn et al. 1985: 91). Soils are “open” systems in which transformations are driven by a continuous flux of matter and energy acting on a progressively altered parent material (Chadwick and Chorover 2001: 324). Most soils contain mixed clay assemblages, some of which retain relict features and reflect varying rates and reversibility of chemical processes.
<table>
<thead>
<tr>
<th>Technique</th>
<th>Uses and Advantages</th>
<th>Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disturbed Samples</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age-depth comparisons</td>
<td>Sedimentation rates</td>
<td>Problematic application of uniformitarian principles if subject to periods of soil formation and human disturbance</td>
</tr>
<tr>
<td>Calcium carbonate (CaCO₃)</td>
<td>Pedogenesis, taphonomy, and site formation</td>
<td>Strongly influenced by postdepositional processes</td>
</tr>
<tr>
<td>Major and minor elemental analyses (AAS, ICP-MS, XRF)</td>
<td>Elemental composition, elemental mapping, weathering, and trace element distributions</td>
<td>Extreme detail often not needed and of limited use if minerals composed of common elements</td>
</tr>
<tr>
<td>Mineral magnetism</td>
<td>Identify sediment sources (tephra, topsoil, subsoil), burning, and human practices at sites/across the landscape</td>
<td>Problematic to disentangle fermentation effects, limited value in some mineralogical environments</td>
</tr>
<tr>
<td>Particle size analysis</td>
<td>Physical composition, general stratigraphic, provenance, and depositional information</td>
<td>Averages microstratigraphy (no information on aggregates), limited use for soils with high clay and organic contents</td>
</tr>
<tr>
<td>pH (acidity/alkalinity)</td>
<td>Soil processes, taphonomy, and site formation</td>
<td>Strongly influenced by contemporary processes</td>
</tr>
<tr>
<td>Phosphate (PO₄³⁻)</td>
<td>Human and animal additions at sites/across the landscape</td>
<td>Debatable theoretical base except for simplest comparative uses</td>
</tr>
<tr>
<td>Scanning electron microscopy (SEM)</td>
<td>Morphology of mineral grains and clay crystals, weathering stages/phases</td>
<td>Extreme detail often not needed in archaeological studies and can be difficult to meaningfully relate to archaeological information</td>
</tr>
<tr>
<td>X-ray diffraction (XRD)</td>
<td>Mineral composition and weathering</td>
<td>Unreliable if large amounts of X-ray amorphous material, such as organic material and poorly ordered clay minerals</td>
</tr>
<tr>
<td>Undisturbed Samples</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scanning electron microscopy (SEM)</td>
<td>Microstructure, microcomposition, and weathering</td>
<td>Extreme detail often not needed in archaeological studies or to understand site formation processes</td>
</tr>
<tr>
<td>Thin-section description (transmitted/cross-polarized/reflected light)</td>
<td>Microstratigraphy, pedofeatures, taphonomy, and some land uses (e.g., cultivation techniques, animal husbandry, settlement use)</td>
<td>Expensive and time-consuming, qualitative information, evidence of former human activities not always preserved</td>
</tr>
<tr>
<td>Thin-section analysis using energy dispersive X-ray analysis (EDXRA)</td>
<td>Elemental compositions, elemental mapping, and weathering</td>
<td>Limited use among minerals composed of common elements, such as highly weathered clays</td>
</tr>
<tr>
<td>X-radiography of sediment slices and large thin sections</td>
<td>Comparative analysis of sedimentary and pedogenic processes, potential for land use studies, invaluable in wetlands and waterlogged deposits</td>
<td>Variable value depending on contexts and sample stability</td>
</tr>
</tbody>
</table>
chemistry is particularly significant in determining weathering pathways and rates, with some reactions between secondary clay minerals being reversible given changing pH, cation concentrations, and REDOX potential. Several other factors, including climate, drainage, and vegetation, complicate the sequence of clay mineral formation, as noted for Highland New Guinea (Chartres and Pain 1984: 147–48).

As Bohn and associates (1985: 68) state: “Soil development, in the chemical sense, is roughly synonymous with weathering.” The extent of chemical weathering is reflected in the mineralogy of different fine earth fractions (that is, clay, silt, and sand). Through time, primary minerals (mainly sand and silt fractions) are transformed to secondary minerals (mainly clay fraction) with increasing alteration with time. The relative stabilities and susceptibilities of minerals to chemical weathering are generally known (Bohn et al. 1985: 79) and are dependent on soil water geochemistry, principally solute concentrations and pH (Nemecz 1981: 494). A combination of mineralogical, chemical, and magnetic assessments is usually sufficient for the archaeologist to reconstruct major sedimentary events and pedogenic periods, but the inherent complexity of soil chemistry and the use of bulk samples often prevent more sophisticated interpretations.

### Undisturbed Samples: Multiscale Investigations

Hodgson has stated that comprehensive field descriptions of soils and sediments “provide an almost indispensable background to local studies whatever their purpose” (Hodgson 1978: 1–2). However, within archaeology, and inscribed within single-context recording systems in particular, is a presumption that the “units of stratification” (Harris 1989: 42) and interfaces (Brown and Harris 1993: 14) identifiable in the field represent significant relict characteristics: “It is often regarded as axiomatic that the properties viewed in a freshly cleaned and exposed archaeological deposit represent the information required for primary archaeological archive and subsequent interpretation” (Barham 1995: 147).

Barham (1995: 147–51, 155–58) has criticized this position by highlighting the “methodological divergence” and practical and theoretical problems of unit and interface identification in different branches of soil science and sedimentology. His main concern is an inability to differentiate original formation (primary) and successive (secondary) microscale investigations can be undertaken to verify field-based macro-scale interpretations, to determine the preservation of primary attributes, and to investigate the palaeoenvironmental and archaeological significance of each unit and interface.

### Mixed-Method Geoarchaeological Analysis

Canti (1995: 186) advocates the adoption of mixed-method approaches to geoarchaeological analysis because “overlaid” multitechnique investigations greatly improve interpretative resolution. For example, the archaeologist will want to know what may have caused decreases and increases in sedimentation rates at a site through time. Were increases in sedimentation rate due to people disturbing and clearing forest in the catchment, or were they the result of climate change or a volcanic eruption? Only through the application of additional geoarchaeological analyses, such as mineral magnetics and thin section description, can the types and origins of increased sediment input be determined (for example, whether they are derived from subsoil or topsoil, and whether they consist of particles or aggregates). Furthermore, a combination of geoarchaeological and biological analyses enables more complex interpretations of landscape change; for example, phytolith, pollen, and charcoal (macro- and micro-) studies can be used to reconstruct burning and vegetation histories for the landscape that can be compared to sedimentation and soil formation histories. More detailed examples of mixed-method geoarchaeological investigations are presented below.

### Scales of Practice

Depending on the nature of the project, we may seek to understand an individual practice that is fixed within a local situation and limited temporal span (for example, the digging of a ditch or the use of a stone tool [Haslam 2006]), or we may seek to understand the cumulative effects of individual actions through time across a landscape (for instance, the creation of an “agricultural landscape” [Haberle 2003]). Perhaps, though, the ultimate goal of archaeology is to understand the indeterminate relations between individual actions and broader social structures and environmental processes (after Hodder 1999). For example, the interrelatedness of individual practices, such as digging a ditch, and larger-scale processes of landscape and social formation need to be understood and char-
Figure 46.2  Geoarchaeological interpretation of early and middle Holocene plant exploitation at Kuk Swamp, Upper Wahgi valley, Papua New Guinea (reproduced with permission from Denham et al. 2003: fig. 2).
Environmental archaeology, especially geo-archaeology, provides a means to understand and manage scalar issues of time and place. A geoarchaeological approach directs us to situate archaeological remains within their environmental context. The intention is to integrate archaeological evidence representing discrete periods of former human activity to long-term practices and environmental processes in the landscape. Different issues of temporal and spatial resolution are associated with understanding landscape change through time (diachronic) and with understanding practices-in-the landscape at points in time (synchronous) (see also Head, this volume; Heilen et al., this volume). To exemplify this, episodes of wetland manipulation and drainage during the early and middle Holocene at Kuk Swamp in Highland New Guinea can be depicted in such a way that archaeological remains of former (synchronous) practices (see Figure 46.2b–d) articulate with the chrono-stratigraphy, which represents (diachronic) processes of long-term landform development along the wetland margin (see Figure 46.2a). However, each discrete set of practices documented on the wetland margin can be examined in greater or lower historic-geographical resolution.

If we consider practices dating to ca. 10,000 years ago at Kuk, it becomes clear that we can employ a range of techniques to provide both more general and more specific understandings of what was happening at that time. From the features documented in a single excavation trench, we can hone in on practices and environmental processes occurring at higher resolution. The field recording of stratigraphy documents major (macro-scale) and minor (micro-scale) stratigraphic units as well as the edges and fills of features (Figure 46.3a-b; see also Harris 1989); it is fundamental to and orients more detailed analyses (see Stern, this volume). Higher resolution (meso-scale) techniques such as X-radiography and thin section description can be used to investigate soil formation within feature fills (Figure 46.3b; see also Krinitzsky 1970) and potentially to investigate the mode of aggregate composition, formation, and microfossil deposition within individual feature fills (Figure 46.3c-d; see also Courty, Goldberg, and MacPhail 1989). The analytical precision of higher resolution techniques was intended to identify pedological evidence of past plant exploitation practices. In this case, there is evidence for a relatively shorter period of drier conditions on the wetland margin and the formation of an immature soil profile, which, in turn, is augmented by archaeological and archaeobotanical tuberous plants on adjacent surfaces at this time (Denham 2005).

From the same starting point, an excavation trench, we can broaden our spatial focus to consider the relationship of the archaeological finds exhibited in plan (Figure 46.4a) to the landform at that time (Figure 46.4b). Features associated with digging, staking, and microtopographic manipulation occur on areas of higher ground adjacent to a palaeochannel. For some, this 10,000 year-old palaeochannel is artificial and indicative of agricultural practices at this time, whereas I am more circumspect (see debate in Denham, Golson, and Hughes, 2004: 267–78). Irrespective of the exact type of plant exploitation practices in this locale, we can draw on archaeological and palaeoecological findings from across the Upper Wahgi valley to envisage the landscape at this time (Figure 46.4c). These landscape-scale reconstructions creatively draw on empirical information, albeit with some chronological conflation of evidence and inferences drawn from ethnography, to develop interpretations of people living across, in and through this landscape 10,000 years ago.

**Complementarity, Integration, and Specificity**

Landscapes are the product, in part, of a way of life. The naming of a landscape in terms of a particular lifeway (for example, agricultural, industrial, pastoral) may be as misleading as it can be illuminating. Numerous and diverse types of practice with highly variable spatial and temporal manifestations become inscribed on a landscape through time. How can this diversity and complexity of co-occurring and superimposed practices in a landscape be encapsulated by archaeological research?

The historical development of the Upper Wahgi valley has been likened to the production of an agricultural landscape (Haberle 2003); it has been produced through the interplay and co-occurrence of numerous types of practice that have their own temporality, spatiality, and visibility. For example, some burning, clearing, gathering, tending, and transplanting practices have a greater antiquity than others do and occurred widely across the landscape; these are only generally inferred from palaeoenvironmental proxies (for instance, charcoal, phytolith, and pollen analyses and rates of sedimentation). In contrast, other practices, such as ditch construction, mound construction, processing of plant parts, and tilling the soil are more recent, have more restricted distributions (in terms of both location of practice and preservation), and
Figure 46.3  Issues of geoarchaeological resolution I: from excavation trench to palaeosol: (a) field recording of excavation trench in plan view; (b) field recording of stratigraphy in the walls of an excavated trench; (c) X-radiograph of feature fill showing limited aggregate development at the base (courtesy of Dr. Alain Pierret); and (d) thin section photomicrograph of pedofeatures.
Figure 46.4  Issues of geoarchaeological resolution II: from excavation trench to landscape:
(a) archaeological features recorded in the base of excavated trenches; (b) archaeological finds in landform context; and (c) interpretation of human-environment interactions across the landscape.
archaeobotanical, and stratigraphic investigation. However, the integration of more general palaeoenvironmental information (relatively low historicogeographic resolution) with archaeological findings (greater specificity and historicogeographic resolution) can contribute to more complex scenarios of practices in the past.

In the Upper Wahgi valley, palaeoecological data provides an impression of how the vegetation has changed through time (Figure 46.5). The causes of those transformations can be only inferred from general patterns of how the forest cover has declined, disturbed habitats expanded and persisted, and burning increased through time. These palaeoecological signals are usually considered representative of an anthropic landscape (Haberle 1994). For example, the lowland montane forests in the Kuk vicinity were already disturbed in the early Holocene. Pollen taxa frequencies suggest persistent, if spatially variable, disturbance using fire and the creation of vegetation mosaics comprising secondary forest, regrowth and grassland within the

But what practices opened up the forest at this time? Faunal analyses from sites across the Highlands suggest hunting was ubiquitous (Mountain 1991), but other inter-montane valleys do not witness forest clearance at this time. Archaeobotanical data from Kuk suggest broad-spectrum plant exploitation was important at this time, which included the exploitation of a starch rich aroid and yam (Fullagar et al. 2006), as well as possibly *Eumusa* bananas that were in the landscape from 10,000 years ago (Denham et al. 2003). These findings implicate plant exploitation practices as drivers of landscape change, potentially through the deliberate creation of habitats conducive to the growth, transplanting and (possibly) cultivation of edible plants. Gaps within the forest may have been enhanced or created through ring-barking, clearance, and burning. Here the complementarity of multidisciplinary approaches is significant. Higher resolution archaeological information, primarily representative of on-site practices, grounds general palaeoecological trends and enables more specific

**Figure 46.5** Complementarity and integration of archaeobotanical and palaeoecological information: (a) summary pollen and microcharcoal diagram with descriptions (reproduced with permission from Denham et al. 2004b: fig. 6); (b) photomicrographs of phytoliths, starch grains and a seed of starch-rich plants used or present in the landscape 10,000 years ago (reproduced with permission from Denham et al. 2003: fig. 4; Fullagar et al. 2006: fig. 8).

<table>
<thead>
<tr>
<th>Age: 7000 cal BP</th>
<th>Environment: Open grasslands, planted bananas with regular burning. Climate: Present climate conditions with high ENSO variability.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age: 9000-7400 cal BP</td>
<td>Environment: Mosaic of Pandanus and grassland swamp with increasingly drier margins. Climate: Warmer than present (1-2°C), mild and low ENSO variability.</td>
</tr>
<tr>
<td>Age: 10000-9000 cal BP</td>
<td>Environment: Mosaic of Pandanus and wet grass swampland with common Typha. Climate: Warming with increased moisture and atmospheric CO₂.</td>
</tr>
<tr>
<td>Age: 22000-10000 cal BP</td>
<td>Environment: Mixed Montane Forest with open swampland and grassland periodically burnt. Climate: Atmospheric CO₂ cooler than present, higher ENSO variability, and drier with increasing atmospheric CO₂.</td>
</tr>
<tr>
<td>Age: Late Pleistocene (&lt;22000 cal BP)</td>
<td>Environment: Mixed montane-Nothofagus forest. Climate: Cool, moist.</td>
</tr>
</tbody>
</table>
Conclusions

Given the vast range of subdisciplines and techniques encapsulated under the labels of environmental archaeology and geoarchaeology, this appraisal has been selective and designed to complement other contributions to this Handbook. I have drawn on conceptual and methodological issues arising during my research, but these are of general relevance and applicability. These issues are not restricted to one field or one technique, rather they cross-cut traditional spheres of concern and are relevant to the interpretation of past practices-in-the landscape.

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References


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