This chapter introduces the role of invertebrates in landscape archaeology by providing a synopsis of their analysis and interpretation in terms of climate and local environment. It draws on the rapidly expanding literature of palaeoecology and environmental archaeology dealing with nonmarine mollusks and insects, and cites sources for further reading. A brief overview is provided for several other taxonomic groups less frequently encountered in the archaeological record or in other contexts that may be informative regarding the nature of archaeological landscapes. The role of invertebrates in physically structuring the archaeological and palaeoecological record is not examined (see Carter 1990; Stein 1983, 2001).

The term *invertebrates* refers to a wide range of unrelated animal taxa; "terrestrial invertebrates" commonly refers to "nonmarine" taxa and thus also includes a range of taxa found in saline and freshwater environments on land. Important terrestrial invertebrate groups include: the annelids (for example, earthworms, leeches); the mollusks (for example, snails, slugs); and the arthropods, which include millipedes and centipedes, crustaceans (for instance, crabs, crayfish, prawns, ostracods), arachnids (for example, spiders, ticks, mites, scorpions), and insects (for instance, beetles, bugs, butterflies/moths, earwigs, cockroaches) (for details see Barnes et al. 2001).

In terms of species richness, the invertebrates dominate the biota of both temperate and tropical regions (Wilson 1992); estimates suggest that more than 70% of the planet's diversity is invertebrate and that about 20% comprises species belonging to one insect order alone, the beetles (Hammond 1995). Of the groups listed above, however, few are frequently preserved in the archaeological or palaeoecological record. Two groups that are commonly preserved and often species-rich, especially in alkaline and anaerobic sediments, respectively, are the nonmarine gastropods—regularly referred to as "land snails"—and the insects. Both are frequently utilized to provide data on the nature of the archaeological sites and their settings. In particular, they provide evidence on the environmental setting of archaeological sites including climatic reconstructions, the nature and extent of altered and constructed landscapes, and the specific environs in which people lived.

### Nonmarine Mollusks

#### Background

Nonmarine mollusks include pulmonate ("lunged") gastropods, prosobranch ("gilled") gastropods, and...
bivalves. Contrary to expectations, not all pulmo-
nates are terrestrial, with a range being truly aqua-
tic, and several families of prosobranchs contain
mainly terrestrial taxa. In common usage, the term
snail refers to the coiled gastropods; however, a
range of pulmonate taxa take other forms with
uncoiled limpet-like shells or the complete reduc-
tion of the shell to an internal “cyst,” (as present
in slugs of several families). A few bivalve families
are common in freshwater lentic (still water) and/or
lotic (flowing water) habitats.

**Preservation and Taphonomy**

Nonmarine mollusks are generally preserved as
aragonite and/or calcite shells and require deposi-
tion in carbonate-rich environments for preserva-
tion (Goodfriend 1992); strongly acidic sediments
will rapidly dissolve even the most robust non-
marine mollusk. Preece and Bridgland (1999:
figs. 22-24) illustrate a sequence from Hollywell
Coombe in southern England that clearly shows
the influence of depositional environment on
preservation: nonmarine mollusks are consist-
ently present in chalkrich sediments and tufa
but are absent from a thin organic layer where they
have not been preserved. An advantage of
nonmarine mollusks is that they are commonly
preserved in settings where most, if not all, other
types of organic remains have been removed
through aerobic microbiological activity. This is
especially true of both open sites (in alluvium,
colluvium and soils, and so on) and rock-shelter
and cave sites (Evans 1972; Thomas 1985). In
organic sediments where nonmarine mollusks
may be absent (as in the example above), other
taxa, (for example, plant and insect macrofossils)
are likely to be preserved, providing an alterna-
tive means of environmental reconstruction (see
Fairbairn, this volume; Rowe and Kershaw, this
volume).

**Sampling, Recovery, and Identification**

Nonmarine mollusk assemblages can be sampled
from cores and open sections or during excava-
tion. Sediments are disaggregated and washed
through sieves, usually 500 um or 1 mm, depend-
ing on the nature of the fauna, then dried, after
which the mollusk remains picked from the con-
centrate: Figure 45.1 shows examples of typical
nonmarine mollusk assemblages from prehuman
and historic levels of Makauwahi Cave, Kaua‘i,
Hawai‘i. Identification is by comparison with
identified reference material, using keys or illus-

Bell and Walker (1992), Evans (1972), Lozek
(1986), Shackley (1981), and Wilkinson and
Stevens (2003).

**Environmental Interpretation**

The modern origin of the use of nonmarine mollusks in archaeology and palaeoecology can be traced to the pioneering work of Sparks (1961, 1969), expanded and refined by Evans (1967), culminating in the publication of the seminal *Land Snails in Archaeology* (Evans 1972). Evans’s primary interest was in the role that land snails played in reconstructing vegetation structure and, therefore, potentially, the impact of people on local and regional environments. The absence of other forms of biological evidence in many archaeological sites and their regional settings has meant that the use of land snails has become commonplace in many parts of the world, at least when compared with the use of other invertebrate remains.

In mesic temperate and tropical regions, most
land snails and slugs are physiologically tied to
certain micro-environments by their inability to
withstand desiccation. This is less true, however,
in arid areas where many species have adapta-
tions for coping with long dry periods. Latitudinal,
alititudinal, and regional scale patterns of distri-
bution also illustrate the influence of thermal
environment, with significant levels of turnover
from cold to warmer habitats. Recognition of cli-
matic influences on the distribution of nonmarine
mollusks has culminated in the development of
methods for the quantification of past climates,
especially temperature, using nonmarine moll-
usk assemblages (Moine et al. 2002; Rousseau
1991; Rousseau et al. 1994; Rousseau, Preece, and
Limondint-Lozouet 1998) and examination of the
climatic significance of morphometric variability
of individual taxa (e.g., Rowe et al. 2001). At the
local scale, micro-environmental conditions are
determined by the interaction of effective precipi-
tation (reflecting temperature and rainfall), sub-
strate type, and vegetation structure, especially
its density. The distribution of nonmarine aquatic
taxa is influenced by water regime (including
flow rate, chemistry, turbidity, substrate, macro-
phyte coverage) and climate, although, for obvi-
ous reasons, moisture regimes are not directly
influential.

Early work on the nature of southern English
landscapes based on data from valley bottoms and,
in the latter half of the Holocene, archaeological
sites—including ditch fills and soils from under
snail analysis could make to the archaeology of chalk landscapes (Evans 1971, 1972; Kerney 1966; Kerney, Chandler, and Brown 1964). The replacement of postglacial open country by woodland, which became increasingly dense and diverse by the middle Holocene, was disrupted by the late Mesolithic and especially Neolithic clearing of the forest for conversion to grazing and ultimately, usually later, to arable land. The rich woodland land snail faunas, dominated by shade-loving taxa, were replaced by less diverse assemblages, including taxa characteristic of open habitats like grassland. Thus, the Neolithic landscape, which included monuments such as Stonehenge, was largely open rather than wooded and contrasted with the contemporary view that these monuments were constructed in wooded landscapes (Wilkinson and Stevens 2003). Recent research has modified this story somewhat, adding regional and temporal complexity by indicating, for some sites, that the major episode of forest clearance occurred during the Late Bronze Age, whereas at others open vegetation was created and maintained from the Mesolithic (for examples, see Allen 1997; Bell 1983; French and Lewis 2005; Preece and Brigland 1999).

A similar but probably less well known story has been revealed on islands across the Pacific, where studies of nonmarine mollusk assemblages were by Kirch (1973, 1975) of assemblages from sites from the Marquesas and Moloka‘i in Hawai‘i, and later from Tikopia (Christensen and Kirch 1981). Across the Pacific, where nonmarine mollusk analyses have been undertaken, several trends recur. Many islands, especially the larger and high islands, have (had) extensive endemic radiations that were heavily affected by the activities of prehistoric people to the extent that many species disappear from the record (and often the planet) following Polynesian arrival (Brook 1999; Burney et al. 2001; Christensen and Kirch 1986; Dye and Tuggle 1998; Neuweger, White, and Ponder 2001; Preece 1998; Solem 1990). Although the exact causes of these extinctions and extirpations are far from certain, a range of factors have been suggested, including: predation by the Pacific Rat (*Rattus exulans*), especially for larger taxa; forest clearance for agriculture and other activities; massively increased fire regimes; and possibly predation by Polynesian-introduced arthropods, especially ants (Burney et al. 2001; Dixon, Soldo, and Christensen 1997; Kirch 1982; Preece 1998).

In prehistory, a range of species, common in early archaeological sites, but absent from pre-human-arrival sediments, dispersed across the Pacific in association with people (Cowie and Grant-Mackie 2004; Kirch 1973, 1993; Preece 1998; Rolett 1992). Essentially, this recurring history is...
landscape resulting in a cascade of extinction that is repeated, with increased intensity, following the arrival of Europeans across the Pacific (Cowie 2001; Cowie and Robinson 2003).

**Insects**

**Background**

The insects are an incredibly diverse group of organisms that are found in all regions of the world, increasing in diversity towards the tropics. The class Insecta contains around 30 orders, some with fewer than 100 species and others with tens to hundreds of thousands of species (for example, beetles [Coleoptera]; ants, wasps, and bees [Hymenoptera]; butterflies and moths [Lepidoptera]; flies [Diptera]; and true bugs [Heteroptera]). Flies belonging to the family Chironomidae, generally referred to as chironomids, are an abundant and informative group in aquatic settings where they are represented by their identifiable head capsules (Brooks and Birks 2001; Hofmann 1986; Walker et al. 1991). They provide evidence for past water temperature, salinity, and nutrient status, although they are infrequently used in specifically archaeological settings.

**Preservation and Taphonomy**

Most archaeological sediments do not contain insect assemblages. They have frequently been oxidized under continuous or intermittent aerobic conditions (cf. nonmarine mollusks). There are two primary contexts, however, in which insect fossils are commonly preserved in archaeological settings: (1) anaerobic sediments from waterlogged contexts and (2) perpetually dry sediments such as those occasionally found in caves, rock-shelters, dwellings, and in extremely arid regions (Buckland 1976; Elias 1994). In some circumstances, associated noncultural deposits may exist that provide the opportunity to examine assemblages coeval with the archaeological deposits providing an environmental context that would be otherwise lacking (Elias 1986).

One factor that is readily apparent from the composition of fossil insect assemblages is that some groups preserve far more commonly than others (for example, Coleoptera, Hymenoptera, Heteroptera, and Trichoptera—caddis-flies), whereas others are extremely rare (for instance, Lepidoptera, Orthoptera—crickets and grasshoppers, Thysanoptera—thrips). the relative robusticity of the groups: beetles are generally strongly sclerotized, whereas butterflies are not. A range of studies have examined potential taphonomic influences on archaeological assemblages by detailed analysis of modern assemblages in relation to their context (e.g., Carroll and Kenward 2001; Kenward 1975, 1985, 1997, 2006; Kenward and Carroll 2006; Osborne 1983; Smith 1996).

**Sampling, Recovery, and Identification**

Sampling and extraction of insect fossils from archaeological sediments is best undertaken in concert with, or by, the insect analyst. In general, the larger size of individual insect fossils and their lower density (at least compared with microfossils such as pollen, diatoms, and phytoliths, for example) means that relatively large samples are required, usually more than a kilogram of sediment and often much more. The variability in the density of fossils and the possibility that they may not be preserved means that it can be wise to assess small samples to provide a clearer regard for further sampling requirements. For waterlogged sediments, recovery of insect fossils is primarily through the use of kerosene floatation after disaggregation. Further details regarding sampling, processing, sorting, and storage of the recovered material can be found in Ashworth (1979), Coope (1986), Elias (1994), and (for specifically archaeological contexts) Buckland (1976), Buckland and Sadler (2000), and Kenward, Hall, and Jones (1980). Identification of insect fossils is a specialist task principally undertaken by fossil insect researchers through comparison with identified modern reference specimens: examples of insect fossils from Pacific contexts are shown in Figure 45.2.

**Environmental Interpretation**

The insects are not only species-rich but also diverse in terms of their environmental requirements. Thus, when the ecology and distribution of the taxa in the archaeological record are well known, the local environment can be reconstructed in detail. Insects provide evidence of a wide range of critical environmental parameters including information on the vegetation (including its specific composition), the soil-surface interface, aquatic environments, presence and nature of organic debris (dead wood, refuse, dung, carrion), and climate (see Ashworth 1979; Atkinson et al. 1986; Coope 1977, 1987;
Figure 45.2 Late Holocene arthropod fossils from Pacific contexts. (A) *Rhyncogonus* sp. weevil head—Makauwahi Cave, Kaua‘i, prehuman sediments: this species is extirpated following Polynesian arrival. (B) Pentatomid bug head—Santa Cruz highlands, Galapagos. (C) Unidentified weevil—Rimatara, French Polynesia, prehuman sediments. (D) Unidentified dermapteran (earwig) forcep—Makawahi Cave, Kaua‘I, Polynesian age sediments. (E) *Pheidole* cf. *fervens* (ant) head, Rimatara, French Polynesia, Polynesian age sediments. (F) Unidentified oribatid mite, Santa Cruz highlands, Galapagos.
synanthropic taxa (including stored product pests) are important and informative components in many archaeological assemblages (Buckland 1981, 1990; Panagiotakopulu 2000). Panagiotakopulu (2001) reviewed records for insect pests, including human ectoparasites, from Egyptian contexts, and noted there is much potential for understanding the origin and the spread of synanthropic taxa. Although current research in this field is focused on northern Europe and the Mediterranean region, there exists much potential for tracing the origin and the spread of pest taxa associated with prehistoric and historic human migrations.

Insect fossils, principally beetles, are routinely utilized in reconstruction of archaeological environments in Western Europe, especially in Britain (see Elias 1994, for a detailed review, and papers in Buckland, Coope, and Sadler 2004). Most research, however, has focused on post-Palaeolithic sites (although see Buckland 1984; Coope 1993, 2006 and references therein; Coope and Elias 2000 for analysis of assemblages from Palaeolithic sites). Assemblages from Palaeolithic contexts provide details of the nature of the local environment of deposition and regional climate, principally in terms of summer warmth and seasonality (Coope 2006). For North America, a range of studies have examined assemblages from open and cave sites, providing a context for several Paleoindian sites (Elias 1986, 1990; Elias and Nelson 1989) although most North American studies have focused on more recent assemblages from habitation sites (for example, Pueblo, Anasazi) or dry-cave sediments (reviewed in Elias 1994). Hoganson and associates (1989) provide an environmental context for Monte Verde, an early Paleoindian site in Chile; the insect assemblage, dominated by beetles, showed that at the time of deposition the setting was rainforest with areas of open ground beside a creek that included rapid, flowing water and areas of still vegetation-rich water.

The majority of European studies focus on the reconstruction of the local environment of sites from the Iron Age to the recent past. The settings of these sites may be essentially natural or heavily modified in the case of habitation/urban settings (for examples see Buckland 1974; Buckland and Kenward 1972; Buckland, Holdsworth, and Monk 1976; Buckland, Beal, and Heal 1990; Kenward and Large 1997; Osborne 1969, 1971; Ponel et al. 2000). In a review of British insect fossil faunas from the past 10,000 years, Dinnin and Sadler (1999: 545) divide the development of the insect fauna into five phases. These phases, not surprisingly inferred from the nonmarine mollusk record noted above: (1) late-glacial-Holocene warming and reinvasion of the thermophilous taxa; (2) early Holocene afforestation and increasing faunal diversity; (3) forest climax with diverse forest obligate community; (4) Neolithic deforestation from the middle Holocene and accelerating from the Bronze Age; and (5) the creation of a “culture steppe.” The final two phases represent the culmination of a temporal and spatial increase in the clearance of forest, extirpation of forest elements, especially those associated with primary forest, and expansion of treeless landscapes. Whitehouse (2006) reviewed the Holocene history of human impact in British and Irish forests and noted that about 40 species of beetles were extirpated from Britain (mainly based on data from England) prior to the period of modern collection. Most of these beetles are characteristically associated with old-growth forest habitats, especially dead wood within these forests, and disappear from the fossil record (and the region) mostly in the period 5,000–2,000 years B.P., reflecting the pattern of increasing clearance and modification of primary forest.

Evidence for human impact on regional biodiversity and its composition has been recovered from the analysis of insect faunas associated with Norse settlement of Greenland and Iceland (Barlow et al. 1997; Böcher 1997; Buckland et al. 1986, 1996; Perry, Buckland, and Snæsdóttir 1985; Sadler 1991; Sadler and Skidmore 1995). Norse settlement in these regions resulted in the introduction of a range of synanthropic taxa that probably remained closely tied to human occupation sites. In Greenland, for example, many died out with the collapse and abandonment of Norse settlements although others apparently survived until the modern era (Böcher 1997).

Examination of waterlogged sediments from archaeological sites in the Pacific has revealed abundant insect, spider, and mite remains in samples that predate human arrival, as well as in samples associated with Polynesian, and subsequently, historic presence. Preliminary analysis of such samples (Porch, unpublished data) indicates a scenario of considerable impact on the biota with Polynesian settlement that accelerated after European arrival. This impact includes both the extinction of a range of taxa and the import of human and agricultural commensals. Such results, albeit preliminary, parallel the land snail results for the Pacific, described above. They foster the belief that there is much greater potential in utilizing invertebrate remains in the process of recon-
the ecosystems of both continents and especially islands than has hitherto been realized.

**Other Taxa**

The remains of mites (see Figure 45.2f) are commonly encountered in fossil insect samples from archaeological and other contexts (Denford 1978; Erickson 1988; Schlevis 1990, 1997). Like insects, mites are informative in regard to the nature of local environments, although their use tends to provide less informative environmental details than those based on, for example, beetles. Studies have indicated, however, that it may be possible to determine the presence and specific origin of dung in sediments on the basis of the encapsulated predatory mite assemblage (Schlevis 1992). Ostracods and Cladocera, calcareous-bivalved and chitinous crustaceans, respectively, are little utilized in archaeological studies; however, like chironomids, they may be present in abundance in water-lain sediments (Frey 1986).

The type of information that cladocerans and ostracods provide (and chironomids)—data regarding the nature of water bodies—is generally not a key interest of those interested in archaeological landscapes. It is not until late in prehistory, more often the industrial age, that humans have sufficiently affected these aquatic ecosystems to cause change in the ecology, and therefore biota, of such systems.

**Conclusions**

The invertebrates are a diverse group of organisms in terms of their taxonomy, ecology, and preservation in archaeological contexts. The contrasting preservation potential of different invertebrate taxa (such as land-snails and insects) means that in sediments that may be devoid of one group others may be present that can yield information regarding the nature and environmental setting of sedimentary sequences. Their ecological diversity means a wide range of general and specific questions about archaeological landscapes can be addressed, including issues about human landscape modification that leave little, if any, traditional archaeological record. They are almost certainly underutilized in landscape archaeology, partly reflecting the ignorance of many archaeologists regarding their potential utility, and mainly because of the specialist nature of invertebrate analysis.

**References**


———. 1984. North-west Lincolnshire 10,000 years


Chapter 45: Terrestrial Invertebrates in Landscape Archaeology


Part V: Characterizing Landscapes

466


