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Applying concepts of scales
4.1 Landscape scale and human mobility: Geoarchaeological evidence from Rutherfords Creek, New South Wales, Australia

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ABSTRACT

The surface archaeological record is abundant in some parts of arid Australia and, if analysed with attention to the history of deposition, it provides an accessible resource with which to assess past landscape use. Here, we report results of studies of the mid-late Holocene Aboriginal occupants of one part of the Australian arid zone, based on analyses of the archaeological record in the 62 km² catchment of Rutherfords Creek in western New South Wales (NSW). We consider the types of behavioural information that can be derived from this record and how interpretation varies when considering different spatial and temporal scales. Those hunter-gatherers, who were highly mobile, traversed areas that were orders of magnitude larger than the areas that can be studied in detail by archaeologists. This requires the development of techniques for inferring the extent of landscape use from isolated spatial and temporal samples. We describe some of these techniques and consider the implications of the results obtained from their application.

INTRODUCTION

The arid regions of western NSW Australia have an abundant archaeological record that is highly visible due to the significant loss of topsoil caused by overgrazing since the late 19th century. Erosion has exposed stone artefacts and the remains of heat retainer hearths that are the legacy of intermittent occupation by Aboriginal people stretching back into the Late Pleistocene. An extensive, visible archaeological record, where stone artefacts and hearths reflect people’s presence in the landscape, offers the opportunity for understanding mobility within a settlement system. However, the temptation to study mobility
via a ‘dots on maps’ approach, i.e. where a map of recorded archaeological remains is interpreted directly as the outcome of the spatial scale of past human behaviour, runs into obvious logistic problems. Australia, for example, has almost the same landmass as the whole of Europe, meaning that geographic regions span areas that incorporate several of the smaller European nation states. It is not feasible to study the archaeological record left by people who, through time, might have traversed thousands of square kilometres. The first aim of this study is, therefore, to consider archaeological approaches that do not require the a priori definition of the geographic boundaries of the region used by hunter-gatherers when considering settlement systems. We illustrate that a great deal can be learnt about how people used space by studying archaeological remains left at individual locations. In so doing, we describe a landscape archaeology that involves making inferences about what went on at a number of locations from what is found at one location.

People undertook different activities in different parts of the landscape at different times and for a variety of reasons. Variability in the archaeological record therefore reflects the variety of these activities. This variability is time-dependent, in the sense that it will tend to increase the longer the period of time considered. It is the outcome of different activities that leads to pattern in the archaeological record, therefore time has to pass for archaeologists to have something to interpret (Holdaway & Wandsnider 2006, 2008).

Previous approaches to landscape definition sometimes sought to identify functional settlement pattern models typified in hunter-gatherer archaeology by reconstructions of a ‘seasonal’ round of activities and the identification of functional site types (e.g. Thomas 1973). These reconstructions were one-dimensional in the sense that they were a-temporal, with spatially defined sets of localities thought to be behaviourally linked in a single system. People were thought to undertake the same activities repeatedly in the same locations each season. In many environments, however, including arid Australia, shifts in the environment do not conform to annual seasonal changes and are better characterised as temporally non-linear (Stafford-Smith & Morton 1990). The second aim of this paper is, therefore, to illustrate landscape approaches that are multidimensional and, at the same time, do not rely on patterns generated by regularly recurring seasonal environmental shifts. Human-environment interaction is reciprocal such that humans both affected, and were affected by, the environment, meaning that through time the nature of the interaction may change. These interactions with the environment are in turn closely tied to the formation of the archaeological record. The analysis of regions by studying single locations provides the means to understand a range of human-environment interactions without proscribing fixed boundaries within which these interactions took place, or requiring that the only mechanism for change is the shift from one stable system to another.

In the research reported here, the understanding of human-environment interactions are geomorphologically and chronologically based since it is from the sediments and other datable materials that we have the best evidence for how humans interacted with the landscape. Processes of erosion and deposition help explain why the abundant artefact record is exposed in the way that it is in Australia, and provide the basis for deriving inferences about how this abundance is to be interpreted. Time and space are closely connected to inferences about mobility, the investigation of which helps to explain how and when people utilised places within the landscape.
Deposits of stone artefacts are currently exposed on eroded surfaces along the edge of watercourses in the western NSW rangelands of Australia (fig. 1), with individual exposures varying in extent from a few hundred to more than 10,000 square metres (Holdaway & Fanning 2008). Erosion is largely attributable to overgrazing by introduced domesticated animals (mostly sheep) beginning in the late 19th century (Fanning 1999). Some of the stone artefact exposures are associated with the eroded remains of heat retainer hearths that provide charcoal for radiocarbon age determinations (fig. 2). When combined with sediment and hearthstone ages obtained using optically stimulated luminescence (OSL), these age determinations permit a chronology of occupation to be established (Holdaway et al. 2005, 2008; Fanning et al. 2008; Rhodes et al. 2009, 2010). OSL age estimates and sediment analyses indicate that watercourses were periodically eroded removing artefacts into sediment deposits in lakes downstream. OSL age estimates of the surfaces upon which the artefacts are now resting provide an indication of the maximum time period over which these artefacts accumulated (Fanning et al. 2007, 2009a) (fig. 3). Radiocarbon age esti-
mates from the hearths post-date the OSL ages obtained from sediments that lie immediately beneath the hearths. Hearth age estimates tend to cluster temporally as well as spatially, suggesting discrete episodes of repeated hearth construction at the same location, with those episodes separated by periods measured in decades to centuries (Holdaway et al. 2002, 2005).

Rutherford’s Creek is an ephemeral stream network draining a catchment area of 62.5 km$^2$ in the semi-arid north-west of the state of New South Wales (fig. 1). Over the four year period from 2005 to 2008, we conducted archaeological and geomorphological surveys along a 15 km length of the main channel, from near the headwaters to the mouth at its junction with Peery Lake, an ephemeral lake basin (fig. 4). The eroding valley floor margin, with an area of 37.8 km$^2$, is comprised of multiple overlapping units of fluvial sediments deposited in episodes spanning the Holocene (Rhodes et al. 2010). Artefact deposits are visible on eroded patches (locally referred to as ‘scalds’ – fig. 5) comprising approximately 2 km$^2$ of the valley floor. The archaeological surveys were confined to a randomly selected sample of approximately 2,364 mapped scalds, amounting to approximately 4.5% of the eroded valley floor by area (fig. 4). A total of 27,108 artefacts were analysed, with an overall density of approximately 0.3 artefacts per square metre. Figure 4 also shows the distribution of the 1,054 hearths that were recorded during the archaeological surveys. Each hearth was initially identified on morphological grounds and confirmed by comparison
Figure 4. Rutherford's Creek, western NSW, showing the location of scalds (i), hearths (ii) and analysed stone artefact assemblages from randomly selected scalds (iii). See also full colour section in this book.
of the magnetic field over the hearth, obtained using a fluxgate gradiometer (Fanning et al. 2009b), with that of the surrounding land surface. A sub-sample of 256 hearths was excavated to obtain charcoal samples, with about one third of these yielding sufficient charcoal for radiocarbon age determinations.

Results indicate that hearths date to the last two and a half thousand years, a pattern that reflects the age of the sediments into which the hearths were originally dug (Holdaway et al. 2008a; Rhodes et al. 2009, 2010) (fig. 3). Unconformities in OSL ages from sediments beneath the surface suggest that erosion and deposition of sediments has probably resulted from periodic floods in the past (Fanning et al. 2008). This also explains the lack of deeply stratified archaeological deposits in the valley: artefacts were periodically removed by erosion and transported into sediment-choked stream channels, ultimately becoming buried in the sediment deposits in Peery Lake (Fanning et al. 2009a), rather than in stream terraces that are common, for example, in parts of Europe. The end result of similar processes occurring over large parts of the interior of Australia is an archaeological record where preservation of ancient deposits is relatively rare. As a consequence, datable archaeological features appear to show a dramatic increase in abundance during the last 1000-2000 years, thus implying a late Holocene increase in population, whereas in fact this may be a consequence of erosion (Holdaway et al. 2008; Surovell et al. 2009 report a similar pattern in radiocarbon age determination accumulation for North America).

Figure 5. Eroded sediment patch locally described as a ‘scald’.
HUMAN RESPONSES TO ENVIRONMENTAL CHANGE

The environment of the Australian arid zone is marginal for human subsistence, with a distribution of resources that is patchy, of low density, and subject to large fluctuations in abundance (Gould 1991). This partly reflects the episodic nature of rainfall, but also low fertility derived from poor soil nutrients. Places where water and fertile soils co-occur are rare, leading to a patchy distribution of resources. As well, much of the available carbohydrate occurs as wood making it unavailable to mammals (Stafford-Smith & Morton 1990). Western NSW, for example, has an average annual rainfall of less than 250mm and pan evaporation commonly exceeding 2,000mm, meaning that there is a significant net loss of moisture. These averages are further subject to major fluctuations largely connected to El Niño-Southern Oscillation (ENSO) episodes which bring alternating periods of severe drought and higher than average rainfall to large parts of eastern Australia. Most palaeoenvironmental evidence suggests that, during the mid-to-late Holocene, a climatic optimum occurred around 4000 BP, followed by desiccation and aridity from about 3000 BP to about 1500 BP and amelioration up to the present (Holdaway et al. 2002, 2010a). However, the region has always been subjected to marked local climatic variability.

The majority of available water is found in ephemeral creeks, rock holes, and other features that hold water for varying lengths of time following rain. Drought conditions prevail, but are broken by the punctuated and highly localised rainfall events discussed above (e.g. Dunkerley 1999). Areas receiving rain consequently experience brief increases in water availability and relative, though limited, increases in land productivity, while adjacent areas remain dry (Fanning et al. 2007). Aridity placed great limitations on the use of large portions of the landscape. In the Western Desert of Western Australia, with the extended absence of rain, residential groups contracted to more reliably watered portions of the landscape (Gould 1991). If severe drought conditions persisted, populations employed a strategy of territorial abandonment.

A similar pattern is replicated in the NSW archaeological record, albeit at a different temporal scale to that discussed by Gould (1991). Radiocarbon age determinations, obtained from the previously described hearths in Rutherfords Creek, show statistically significant correlations with peaks in the record of Sea Surface Temperatures (SSTs) derived from deep sea cores that provide an indication of Eastern Asian Monsoon activity as well as shifts in the position of the Inter-Tropical Convergence Zone (ITCZ) (Holdaway et al. 2010a). Changes in these systems have a direct impact on Australian continental rainfall, where the southward positioning of the ITCZ and periods of higher SSTs across northern Australia is associated with higher rainfall in northern and central Australia (Sturman & Tapper 2006). In contrast, the same hearth radiocarbon ages show negative correlations with the record of dust movement from the Australian continent retrieved from an ombrotrophic peat bog in the Old Man Range, Central Otago, New Zealand (Marx et al. 2009). The greatest flux in dust deposition occurs during dry periods that are punctuated by flood events, when the sediment deposits that produce the dust are replenished. A high dust flux therefore occurs when La Niña (high rainfall) periods, resulting in fluvial sediment transport to the Australian continental interior, precede El Niño (low rainfall) periods when dry conditions result in aeolian sediment transport offshore. We interpret the results from the SST and dust correlations to mean that hearths were constructed more frequently during periods with higher moisture levels but were constructed less frequently when dust transport was higher and conditions in the interior were likely to have been more arid. A marked variation in occupation intensity is suggested, from little or no occupation during
dry periods to more frequent activity during more moist times (Holdaway et al. 2010a). However, the timing and degree of these environmental changes would have made the prediction of resource abundance particularly difficult. This must be kept in mind when interpreting the pattern presented by the stone artefact assemblages.

**MOBILITY**

From the Rutherfords Creek research described above, it appears that short-term increases in the availability of water and food resources within the valley systems of western NSW, triggered by unpredictable and localised rainfall, produced, over the long term, a patchy archaeological record. In the desert regions of interior Australia, dense artefact concentrations near water courses are separated by diffuse artefact scatters and isolated occurrences. The sparse and unpredictable character of resource distributions in the short-term meant that it was neither easy to spatially target foraging expeditions, nor possible to know precisely where stone suitable for the production of artefacts might be found. While raw material is locally abundant (cobbles of silcrete and quartz are readily available in dry creek channels, and as extensive stone pavements on adjacent slopes, and silcrete cobbles also occur in the form of boulder mantled outcroppings (Douglass & Holdaway 2010), stopping to find and produce tools as each foraging opportunity was encountered had a time and energy cost. The response was a technological strategy based on a generalised tool-kit (Kuhn 1992), or personal gear (Binford 1977, 1979), carried at all time as a 'hedge' against unforeseen needs, but one that did not involve large quantities of retouched tools.

Retouch is rare on stone artefacts in NSW. Most of the retouched tools in the NSW assemblages are categorised as lightly retouched pieces, notches and denticulates, with little indication of substantial resharpening. Even the retouch on typologically defined scrapers is not very invasive. The exceptions are tula adze slugs (bits for flake adzes – Holdaway & Stern 2004), but these account for only a small proportion of the total number of tools. However, while retouched tools are rare, flakes are abundant. Flakes were struck from cores, but there is only limited evidence for substantial predetermination of form through the shaping of core surfaces. Most flakes were struck in a single direction, although the dorsal scars on flakes indicate some flaking from opposed platforms and some indication of core rotation (Holdaway et al. 2004). The exceptions are flakes struck from flake cores (tranchet cores) where core form acted to limit flake morphology. But these forms are rare. Despite the lack of complexity in technology, assemblages show evidence for the selective removal of larger flake blanks and the transportation of these flakes over a variety of distances.

Movement of flakes in the Rutherfords Creek study area was assessed using a method for determining mobility based on the proportion of cortex present on artefacts, the details of which have been widely published and discussed (Dibble et al. 2005; Douglass et al. 2008; Douglass & Holdaway 2010; Holdaway et al. 2010b; Lin et al. 2010). Three steps are involved:

1. The total mass (or weight) of an assemblage is divided by an estimate of the total mass of the individual nodules from which cores were flaked, thus giving an estimate of the number of nodules reduced.
2. Estimated nodule frequency (or number) is multiplied by the average surface area of the nodules. This provides an estimate of the expected cortical surface area that should be present in an assemblage.

3. This value is compared to the actual quantity of cortex observed in the assemblage and is expressed as a ratio.

A variety of test studies have been conducted to demonstrate the accuracy of the Cortex Ratio method for determining cortex proportions in assemblages. Experimental testing by Dibble et al. (2005) and Douglass et al. (2008) provided an initial verification that the method could accurately gauge archaeological cortex proportions. Further testing by Lin et al. (2010) demonstrated the suitability of the measurement of flake surface area and volume used in the calculation of the Cortex Ratio through comparison with results obtained with laser scanning. Douglass & Holdaway (2010) further investigated the method by considering how variation in raw material size estimates might affect Cortex Ratio calculations. The results of these studies have demonstrated the overall robustness of the method and its suitability for investigating archaeological cortex proportions.

Application of the methodology to assemblages from western NSW returns values of the cortex ratio consistently below one, indicating that cortex is underrepresented (Douglass et al. 2008, their table 2). The addition of many non-cortical flakes and cores to assemblages would explain the observed values of the cortex ratio. However, the local abundance of raw materials, as well as surveys of the size of stone cobbles, makes the scenario of extensive raw material importation seem unlikely (Douglass & Holdaway 2010). A more probable explanation for the disparity in cortex proportions is the removal of material from assemblages for use elsewhere. Cortex Ratios less than one reflect a tendency towards the removal of artefacts with a greater cortical surface area to volume ratio than the nodules from which they were produced. This would result from the selective removal of large blanks, blanks that would tend to have cortex on their dorsal surface as a consequence of their size (Douglass et al. 2008). Artefacts with a high proportion of cortex and large surface area, but which are also thin and therefore have a low volume, most affect the Cortex Ratio. The ratio therefore also informs on the shape of the flakes that were removed, i.e. those having a high edge to mass ratio.

The results of the Cortex Ratio calculated for the Rutherfords Creek assemblages indicate some variation in the degree to which flakes were removed (fig. 6). For some scalds, substantial artefact removal is indicated, while for others many fewer flakes were taken away. A few scalds with low artefact densities have Cortex Ratios that show an over-abundance of cortex. Interpreting the spatial pattern indicated by the different Cortex Ratio values requires that the nature of movement be considered, something that is made easier if movement is considered in a number of different ways. Movement frequency (both on an individual and group level) affects the potential for artefacts to be moved in that less movement will result in more artefacts discarded where they were manufactured and greater movement will increase the probability that any one artefact is moved away from its manufacturing location. Therefore, all things being equal, fewer moves will tend to produce increased Cortex Ratio values and more moves the opposite. Movement linearity will affect the linear distance that an artefact will be moved. Movements that are not linear may cover a great total distance but not move the artefact far from the place where it was produced. Linearity can be expressed using the concept of tortuosity. The degree of movement tortuosity ranges from a non-tortuous straight line movement between points to a movement path so tortuous as to
cover a plane without crossing itself. Differences in movement tortuosity therefore represent differences in the thoroughness of landscape usage (Roshier et al. 2008). Low tortuosity (i.e. more linear movement paths) is associated with a higher velocity of movement across the landscape, which will lead to lower values for the Cortex Ratio at any one location. In contrast, high tortuosity, while still potentially involving the transport of flakes, will lead to local deposition and therefore an increased chance that an artefact assemblage at any one location will have a higher Cortex Ratio value. Finally, artefact longevity will have an effect on artefact movement since those artefacts that exist for longer periods of time before being discarded will have a greater chance of being transported over greater distances.

These concepts of movement may be related to environmental resource availability. Concentrated resource patches will encourage higher tortuosity and lower velocity while sparse resource distributions will lead to less tortuous movement and a higher velocity. Between-patch movements across less desirable portions of the landscape will have low tortuosity, while within-patch movements are apt to be more tortuous as more intensive searching for resources occurs.

Applying this reasoning to the Rutherfords Creek study area, we find that there is a lack of pattern in relation to the Peery Lake ‘resource patch’. Rutherfords Creek flows into Peery Lake, a large ephemeral lake basin that when flooded supports a diversity of resources such as fish, birds and grazing animals. What is striking about the distribution of Cortex Ratio values calculated for individual scalds in Ruther-
Fords Creek is that there is no uniform gradation of values towards or away from the lake (fig. 6). In addition, the majority of the scalds, including those that contain the vast majority of the artefacts, have cortex values well below one, suggesting considerable artefact movement. Despite the existence of the lake ‘resource patch’, the Cortex Ratio values suggest that tortuosity of movement was relatively low and velocity high. This suggests that the lake and its immediate surroundings was not sufficiently desirable to encourage place to place movement around its shores in what might be described as a ‘daisy chain’ of occupations. If it had been, transport of flakes from one location to the next would inevitably have led to Cortex Ratios closer to one through repeated deposition of artefacts as people moved from one place to the next in what Binford (1980) has described as a ‘leapfrog’ pattern. Instead, the daisy chain was broken and artefacts were moved a sufficient distance away so as not to be returned.

Both the low Cortex Ratio values displayed by the artefact assemblages, and the results of the hearth radiocarbon age estimates previously described, suggest a series of episodic occupations. Thus, despite the chronology of occupation for Rutherfords Creek spanning around 2000 years, the total amount of time that it was occupied was probably much less. However, the outcomes of a series of short-term manufacturing and movement events are still apparent in a palimpsest deposit that accumulated over more than two millennia.

The long-term consequences of mobility are reflected in variations in the hearth radiocarbon chronologies. As discussed previously, gaps in the distribution of radiocarbon age determinations correlate with multi-decadal shifts in the late Holocene Australian climate (Holdaway et al. 2010a). While not explainable at the temporal scale by the movement of individuals, this pattern does indicate the long-term consequences of a mobility strategy practiced by groups of individuals: populations abandoned locations right across western NSW for prolonged periods of time in keeping with multidecade-long shifts in rainfall.

The transport of large, thin flakes demonstrates an emphasis on artefact selection and transport despite the relative lack of retouched tools, and reflects an organisation of technology geared not to the conditions that persisted in the vicinity of the assemblages where the artefacts were manufactured, but instead to the conditions that existed elsewhere where the artefacts were intended to be used. It suggests that use often occurred at the ‘in-between’ places in the wider Australian landscape. At these places resources might be encountered but these were never concentrated enough or predictable enough to allow prolonged occupation. Interpreted at the scale of a single site or, indeed, a single geographic feature like a drainage basin, the archaeological record shows little understandable pattern in the sense that artefact concentrations do not pattern neatly with geographic features. There is for instance, no simple relationship between the size or complexity of assemblages with increasing stream order (Shiner 2008). However, this lack of pattern does make more sense when used to support an inference of mobility as a response to an unpredictable climate and therefore unpredictable resource base. The same general location might be repeatedly occupied but not necessarily used to exploit the same resource suite or abundance (Holdaway et al. 2008b), and individual targeted areas never represented more than just a part of the greater expanses where stone artefacts might be needed.
Demonstrating that the archaeological record from western NSW shows high levels of mobility should not come as a surprise. It has been known for many years that Aboriginal people in western NSW moved extensively (e.g. Allen 1974) as they did in other parts of the Australian arid zone (e.g. Veth 1993). However, demonstrating mobility poses significant problems for archaeologists. As Close (2000) points out, it is one thing to propose that people should have moved extensively, but quite another to indicate how in fact they did move. The sheer scale of movement provides significant methodological problems. How big should the research area be to encompass the likely size of the settlement system? Some writers in Australia, for instance, have proposed that the spatial organisation of society is best considered at the scale of entire drainage systems (Peterson 1976; Sutton 1990). However, one such drainage system, the Murray-Darling Basin (MDB), covers an area of more than a million square kilometres or 14% of continental Australia. While one individual is unlikely to have traversed such an area, many individuals contributed to the formation of archaeological records found in sub-catchments within the MDB, like that at Rutherfords Creek. The people who formed this record over more than two millennia might be expected to have traversed very large regions at one time or another. If archaeologists cannot possibly survey regions with land areas the size of the MDB, how should they go about placing limits on their study areas and still be able to meaningfully assess the settlement pattern?

When considering this problem, it is useful to distinguish between landscape as a place where people lived, and landscape as a means of understanding variability in the archaeological record. People certainly occupied space; they acted within it, and ‘organised’ it in their own ways. Archaeologists can make inferences about how past peoples conceived of landscape, as we have done based on our western NSW study area (see, for example, Holdaway & Allen in press). However, such inferences come from the results of analysis, and not simply from record description. How people interacted with a landscape is not inscribed directly by the distribution of archaeological materials identified across it. Using landscape as a means to assess variability is a form of comparative analysis. The value that comes from incorporating space into analysis comes from the ability this provides to compare more than one unit of observation. Increasing the number of units will either increase the variability apparent in the record or not. Both results are potentially interesting. Because the incorporation of space increases variability it also enhances the ability to integrate a diversity of data sets and hence processes that produce variability by their operation at different spatial scales. This in turn enhances the ability to determine the outcome of interactions between multiple processes.

Deriving inferences about how people used and perceived a landscape involves investigating a set of places where people lived, among other things. But it is not necessary for the analytical space to equate with the actual space utilised by either multiple groups through time or a single group at one time. As indicated above, the areas involved in either case may be impossibly large. Instead, it is necessary to analyse a sample of places that were used with techniques that allow inferences to be drawn about what the sample means in its wider spatial context. In the Rutherfords Creek study, for example, the archaeological survey ranged across a 15 km long drainage line measurable in a GIS as an area of 62 km². But the inferences about the use of space by Aboriginal people derived from this study area extended over regions and orders of magnitude larger than this.

Considering a sampling unit with a larger area increases the potential that a more variable archaeo-
logical record will be encountered. However, there is no rule on how large or small a sample area should be. At one extreme, one could imagine a group of artefacts representing the activities of one or a group of individuals. Studies of the Meer site published a number of years ago provide one example (Cahen et al. 1979). Precise behavioural inference is possible from such examples but the explanatory power of such inference is limited because it represents the behaviour of only a handful of people at one point in time. There is no indication of the degree to which this behaviour can be generalised to larger populations. At the other extreme, surveying the archaeological record within a geographically defined space like Rutherfords Creek provides information on the intensity of use, but it cannot provide information on the operation of specific groups of people at any one point of time. Stated in this way, it is easy to see that any one analysis is no more correct than the other: both the examples relate to different types of research questions. What should be concluded is that analyses need to be situated at a scale (or set of scales) where the results are not so specific that they are trivial and not so generalised that they appear to apply to nearly every type of archaeological record (Holdaway & Wandsnider 2006).

Much the same point can be made when considering time. More time passing may increase variability, but variability requires increases in the amount of behaviour accumulated at one place, not simply a greater period of elapsed time. The prolonged accumulation of the western NSW archaeological record, all the more apparent because it is both exposed and is a palimpsest lagged onto a single surface, represents relatively little accumulated behavioural time even though it is spread across more than two millennia of elapsed time. The type of behaviour evidenced by the Cortex Ratio suggests movements of artefacts by individuals ‘gearing up’ for long trips that also could be measured in days, although, as argued above, the movements involved sometimes took people away from Rutherfords Creek and they did not return for periods measured in decades or centuries. In any event, analysis reveals examples of a palimpsest of short-term events that occurred over long periods of elapsed time. In contrast, climatic correlations are only apparent when many behavioural episodes are combined together to investigate elapsed time periods measured in centuries. Similarly to the analysis of space, neither one of these analyses is more correct than the other since both address different types of questions. Neither is the behaviour indicated by spatial analysis to be preferred over analyses based on time. Rather, it is the variability introduced by comparing all the types of analyses, aimed at determining behaviour operating at both different spatial and temporal scales, which produces the long-term record of human behaviour.

**CONCLUSION**

In western NSW, Australia, analysis of archaeological remains in a 15 km long drainage system has provided information on the nature of land use and movement over areas that are orders of magnitude larger than those actually studied. The movement of flakes, interpreted as examples of ‘gearing up behaviour’, occurred across distances that moved people well beyond the limits of Peery Lake. On the longer term, the accumulation of hearths indicates how the accumulations of behavioural events relate to long-term shifts in the climate and therefore resource availability.

Hunter-gatherers moved over substantial areas in arid parts of Australia, complicating the task of archaeologists interested in understanding behavioural changes related to human-environment interactions. It is rarely possible to define spatial units that equate with behavioural units in such situations. In
addition, the archaeological record accumulates through time, meaning that multiple behavioural events accumulate within one area. Landscape approaches in archaeology provide the means to deal with the palimpsest of behaviour represented in the archaeological record both spatially and temporally. No one spatial or temporal scale is more suitable than the other but, as both scales are increased, the potential for a more variable record is increased. Archaeologists are able to investigate the variability at different scales as a means for deriving different types of inferences about past behaviour.

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