

Windows on the Past? Perspectives on Accumulation, Formation, and Significance from an Australian Holocene Lithic Landscape

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Abstract: *The generative nature of the archaeological record stands in contrast with reconstructive goals of the discipline. This is particularly evident in discussions of surface archaeology, which is often considered deficient for reconstructing human behavior in the past when compared with subsurface deposits. We look at a case study from Rutherfords Creek in arid southeastern Australia, where lithics and combustion features appear in differing densities across the surface. These have been interpreted variably in terms of settlement patterns; however, the relationships between accumulation, visibility, and preservation are complex. This study addresses these relationships in terms of formation dynamics, drawing out patterns from surface assemblages that bear on the mobility and resilience of the ancestral Aboriginal populations that occupied Rutherfords Creek during the late Holocene. A different view of the record emerges, one that foregrounds the notions of reversibility in the patterning to identify the kinds of questions the record might be most fruitfully brought to bear on, with implications for both surface and subsurface archaeology.*

Keywords: *Australia, landscape archaeology, formation, accumulation, lithic scatters*

Fenster in die Vergangenheit? Einblicke in die Fundanhäufung, Herausbildung und Bedeutung einer Steinartefakt-Landschaft des australischen Holozän

Zusammenfassung: Die generative Natur der archäologischen Überlieferung steht im Gegensatz zu den rekonstruktiven Zielsetzungen der Archäologie. Besonders offensichtlich wird das bei Diskussionen über die Archäologie von Geländeoberflächen, die oft als unzureichend für die Rekonstruktion menschlichen Verhaltens in der Vergangenheit angesehen wird, wenn man sie mit der Archäologie von unter der Oberfläche liegenden Ablagerungen vergleicht. Wir betrachten eine Fallstudie aus Rutherfords Creek im ariden südöstlichen Australien, wo Steinartefakte und mit Feuer assoziierte Befunde in wechselnden Dichten über die Oberfläche verteilt anzutreffen sind. Diese sind in verschiedener Weise im Sinne von Siedlungsstrukturen interpretiert worden. Die Wechselbeziehungen zwischen Akkumulation, Sichtbarkeit und Erhaltungsbedingungen sind jedoch komplex. Indem wir in unserer Studie diese Wechselbeziehungen hinsichtlich ihrer Entstehungsdynamik untersuchen, erkennen wir Muster in den Fundvergesellschaftungen auf der Geländeoberfläche, die Bedeutung für unser Verständnis der Mobilität und der Widerstandsfähigkeit der Ureinwohnerpopulationen haben, die Rutherfords Creek im späten Holozän bewohnt haben. Auf diese Weise entsteht eine neue Sicht auf die archäologische Überlieferung, und zwar eine, die die Vorstellung der Umkehrbarkeit in der Musterbildung in den Vordergrund stellt, um jene Fragen zu ermitteln, auf die der archäologische Befund die aussagekräftigsten Antworten geben kann. Dies hat Auswirkungen sowohl auf die Archäologie von Geländeoberflächen als auch für die Archäologie von Schichten unter der Oberfläche.

Schlagwörter: Australien, Landschaftsarchäologie, Herausbildung, Fundanhäufung, Steinartefaktstreuungen

Introduction

When does the archaeological record begin? This is a question commonly heard in the halls of museums or introductory archaeology lectures, and one that is answered in a straightforward way: it begins with the earliest evidence of human material culture. The oldest well-accepted evidence for material culture are stone artifacts estimated to be approximately 3.3 million years old (Harmand et al. 2015). For contemporary narratives of human cultural evolution, this scatter of flakes and cores sits at the beginning of the trajectory of humanness. At the same time, its presence immediately raises questions about its ancestry and speculation about what came before (Haslam et al. 2016; Lewis and Harmand 2016). To be sure, it is possible to point to earlier periods when stone tools have not yet been found, and later periods when they are known to have existed, thereby establishing the “event” of flaking stone as happening sometime in between. The “events” that produced the artifacts contribute to a palimpsest of accumulation, deposition, and reorganization generated between the limits set by chronostratigraphic determination and the present day.

So perhaps a better way to ask the question is, does the archaeological record have a beginning? Because the archaeological record is a generative record (*sensu* Epstein 2006; see also Lucas 2005, 41; Lake 2015, 24), the organization of archaeological materials is not the combined outcome of human and natural processes transforming the signature of an initial cultural system. Rather it is the emergent outcome of many individual actions through time, human-mediated and otherwise, which change the condition of one or more elements of an ongoing system. As an emergent phenomenon, the record has no definitive beginning, but instead is constantly in a state of becoming (Schiffer 1976; Binford 1981; Bailey 1983; see also Pred 1984). From this perspective, understanding the organizational forces that lead to material organization at a place through time takes the place of constructing linear narratives through time (Bailey 1983; Schlanger 1992; Lucas 2008; Shiner 2009).

In this paper, we will explore the concept of a generative record in a much more recent context: late Holocene surface deposits from semi-arid southeastern Australia. Rather than emphasize post-depositional disturbance, we find that the highly visible condition of surface deposits forces an honest appraisal of temporally structured formation processes beyond those resulting in the discard of objects by people in the past. Using data obtained from surface lithic scatters and heat-retainer hearths, we interrogate two commonly held misconceptions of the temporality of the surface record: the use of density as a measure of occupation intensity, and the conceptualization of taphonomy as a process of decay. In doing so, we seek to reframe archaeological deposits as the outcomes of emergent processes that can inform on the tempo and mode of land use over time.

Surface archaeology

The surface record consists of deposits exposed on presently existing land surfaces. This definition relates to subsurface deposits, those covered (or sealed) by at least one layer of sediment. Surface archaeology is typically associated with geomorphological conditions that limit the obscuring and super-positioning effects of sediment deposition. These may form on a stable surface over time, be combined onto a common surface

through deflation (e.g., Fanning 1994, 1999), or be brought to the surface through mechanical actions such as burrowing and ploughing (e.g. Roper 1976).

The combinations of stable or deflating surfaces and high visibility are conditions commonly found in the worlds' semi-arid and arid zones, and many of these areas were also places where peoples using lithic technologies persisted, in some cases into the near-present (e.g. Gould 1980; Tonkinson 1993). Stone artifact scatters are among the most common types of surface deposits. While these might be found in any place that people using lithic technologies once existed, stone artifacts are normally small objects which can easily become buried or obscured by vegetation, and their investigation by archaeologists depends largely on their visibility.

Perspectives on the value of surface archaeology have changed over time. The survey of surface deposits has long been viewed as useful for detecting underlying stratified archaeological deposits, and is often considered among "the first steps to be taken in deciding where to dig" (Binford 1992, 47). Indeed, artifacts on the surface at Lomekwi 3 led to their discovery (Harmand et al. 2015). Techniques like systematic field walking identify concentrations of archaeological remains on the surface indicating of subsurface deposits (Ammerman 1981; Drewett 1999, 44). The concept of "plough zone" archaeology, surveys of recently ploughed fields, is used as a means of identifying sites (Allen 1991, 39). From this standpoint, surface archaeology is considered highly useful for prospecting but of limited interpretive value.

With the proliferation of ethnoarchaeological studies among contemporary hunter-gatherer societies in the beginning in the 1960s and 1970s, surface archaeology changed into a subject of study in its own right. Ethnographers often found that human behavior was more dispersed than indicated by the concentrations of archaeological materials found in traditionally defined sites (e.g., Yellen 1977; Gould 1980). In a study of Arandic-speaking forager groups in central Australia, for example, O'Connell (1987, 104) noted that, in order to obtain a reasonable approximation of place use, multiple large exposures on an order "at or beyond" the largest known at the time would need to be surveyed.

The approaches to surface archaeology that emerged share a view of the archaeological record as a more or less continuous distribution of discarded materials on or near the surface of the earth (Isaac and Harris 1975; Dunnell and Dancey 1983; Boismier 1991, 14-15; Ebert 1992). The accumulation of materials in some locations relative to others reflects intensity of place use and human activity (Foley 1981; Binford 1982). Methodological developments in survey and data recording, particularly over the past two decades, have significantly reduced both financial and temporal costs in the collection of this volume of data (e.g., McPherron and Holdaway 1996; Galaty 2005; Wheatley 2011; Bevan 2015) while increasingly sophisticated analytical techniques have been employed for assessing spatial patterning (e.g., papers in Hodder and Orton 1979; papers in Gillings et al. 1999; papers in Bevan and Lake 2013). This has provided a foundation for archaeologists to interpret the surface record in terms of behavior which is spatially disaggregated and variable both spatially and temporally (e.g. Binford 1980, 1982; Foley 1981; Wandsnider 1996; Shiner 2004; Foley and Lahr 2015; Riris 2017). However, while the value of surface deposits as indicators of landscape scale place use has increased, the temporality of surface assemblages and their formation histories are still poorly understood (Bailey 2008; Lucas 2012). Being comprised of artifacts and features combined

on a common surface, the primary mechanism by which archaeologists establish chronology, vertical stratigraphy, cannot be used as typically conceived (Harris 1979). The inability to order surface deposits within a stratigraphic sequence leads to concerns over biases in temporal relationships within and between surface deposits (e.g., Clarkson 2008, 493), concerns that are sometimes used to justify a preference for stratified deposits (e.g., Johnson and Brook 2011).

This is mirrored in the management of surface archaeology in heritage sites, where emphasis is often placed on providing cultural interpretation as part of significance assessments. Lithic scatters, for example, are often described using functional descriptions like “campsites”, “workshops”, etc. (e.g., Environmental Operations Unit and Heritage Consulting Australia 1999), implying that the materials encountered in them once existed as parts of a contemporaneous systemic context. These are often considered to be of greater interpretive value based on their degree of “intactness”, or the clarity of their spatial boundedness (Versaggi and Hohman 2008). Cases where temporally diagnostic artifacts are recovered are also preferred, and these are sometimes treated as indicating contemporaneity with features in the surrounding landscape (Schofield 2000).

To an outside observer, the messages on the value of surface archaeology might seem conflicting. Conceiving of the archaeological record as a palimpsest of multiple, potentially unrelated depositional events (Bailey 2007; Lucas 2008) is not consistent with the idea of identifying behavior in ethnographic terms. At the same time, recognizing scientific or heritage value of a record in a perpetual state of flux is not consistent with emphasizing “intactness” at the expense of variability (Bond 2009). Such views necessitate a preconceived notion of an ideal record unknown in reality, whether that record is presently on the surface or buried (Binford 1981). These counteracting motivations can hinder the proper integration of surface archaeology into historical and prehistorical frameworks, and can potentially undermine their management (Versaggi and Hohman 2008; Bryant 2013).

Rutherfords Creek: a lithic landscape in arid Australia

Rutherfords Creek is an ephemeral stream that runs 13 km along a roughly west-east axis, draining into similarly ephemeral Peery Lake in western New South Wales, Australia. The land around the creek catchment is mostly under 250 m elevation and flat, bounded by low, stone-mantled hills that separate it from other creek catchments on the lake’s western flank. Irregular local storms can, depending on their magnitude, produce standing water in the lake and in creek pools for periods up to a few years at maximum. The lake is also part of a system of overflow basins associated with the Paroo River, and flooding in that system can fill the lake (but not the creeks) even in the absence of local rainfall.

The landscape of Rutherfords Creek is marked by shallow, mostly unvegetated patches of exposed subsoils known as “scalds” (Fig. 1). Scalds form when looser topsoils are removed by wind or water, revealing a smooth, indurated soil surface underneath (Warren 1965). Scalds are resilient to the low-intensity surface erosion processes that expose them, and heavier clasts lag on scald surfaces. While “scald” is a term unique to Australia, analogous geomorphic phenomena featuring sediment deflation and lagged

archaeological deposits are known in many other parts of the world (e.g., Wandsnider 2008; Kandel and Conard 2013).

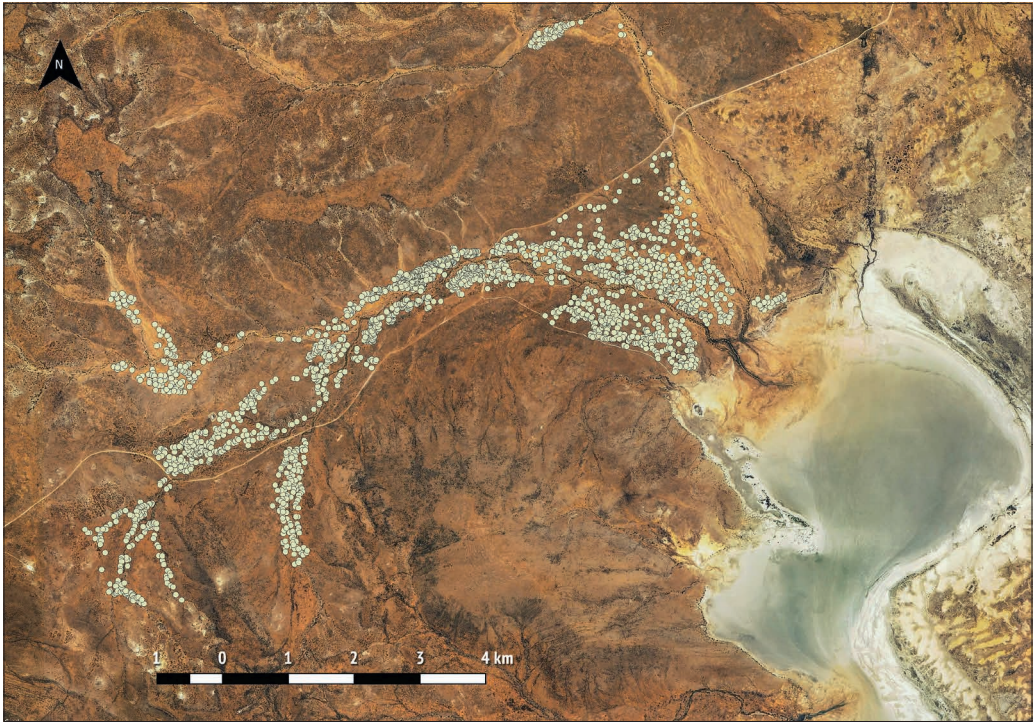


Fig. 1: Locations of scalds in Rutherfords Creek study area, New South Wales, Australia (base map: Google).

Scalds around Rutherfords Creek, and in many parts of Australia, often feature scatters of lagged stone artifacts (Fig. 2). A total of 25,338 stone artifacts were recorded from a random sample of scalds representing approximately 5% of the exposed surfaces in the creek valley by area. While many formal tools were identified at Rutherfords Creek, the vast majority of artifacts are flakes and cores lacking retouch (Table 1). Raw material is abundant in all parts of Rutherfords Creek, occurring in rocky outcrops, cobble-lined creek beds, and stony desert pavements called “gibbers”. The dominant raw materials in scald assemblages are silcrete (89.4%) and quartzite (10.3%), both found in abundance locally, as well as a handful of other local and non-local sources in smaller amounts (<1%).

In addition to scatters of stone implements, the remains of heat-retainer hearths are also common. These are present in a number of different forms, usually as dense aggregations of fire-altered rock, sometimes concentrated within caps of baked sediments (Fig. 3). These features were formed by lining a shallow hole with heat-retainers such as stones, clay balls, or pieces of termite mounds, and then cooking food in ashes atop the heat-retainers (Holdaway et al. 2017). Over time, the sediments surrounding these features eroded, exposing caps of rock and sediment. As the caps eroded, the heat-retainers

became dislodged and the shape of the hearth indistinct. In some cases, the persistence of a sediment cap created localized relief inversion, so that dislodged heat-retainers formed a 'halo' structure around the former loci of the hearth (for examples, see Fanning et al. 2009a).



Fig. 2: Scald featuring lithic scatter at Rutherfords Creek.

Artifact class	% of total recorded	n
Complete Flake	45.37%	11,518
Distal Flake	13.10%	3327
Angular Fragment	9.20%	2335
Proximal Flake	8.56%	2173
Complete Split	6.94%	1762
Core	5.48%	1390
Complete Tool	4.21%	1068
Medial Flake	2.75%	698
Distal Tool	1.04%	264
Proximal Split	0.89%	227
Broken Split	0.64%	163
Angular Fragment Tool	0.53%	135
Proximal Tool	0.40%	102
Broken Complete Flake	0.30%	77
Complete Split Tool	0.16%	41
Medial Tool	0.15%	39
Milling Slab Fragment	>0.1%	24
Hammerstone	>0.1%	17
Muller	>0.1%	14
Proximal Split Tool	>0.1%	4
Complete Bipolar Core	>0.1%	3
Medial Split Tool	>0.1%	3
Chopper	>0.1%	2
Axe	>0.1%	1
Block	>0.1%	1
TOTAL		25,388

Table 1: Stone artifact classes recorded at Rutherfords Creek. Artifact classes showing retouch are shaded grey.



Fig. 3: Partially exposed heat-retainer hearth exposed on an erosion escarpment at Rutherfords Creek.

The remains of heat-retainer hearths sometimes contain charcoal that can be used for radiocarbon dating (Fanning et al. 2009b; Holdaway et al. 2010). Most of the hearths from Rutherfords Creek date to within the last two thousand years, with a few extending back into the mid Holocene. Periodic gaps occur in the radiocarbon chronology obtained from these hearths, and recent research indicates that this may result from episodes of widespread geomorphic instability over time (Fanning et al. 2007; Davies et al. 2016; see below).

While earlier models presented Australian desert culture as conservative since the end of the Pleistocene (Allen 1972; Gould 1977), recent behavioral narratives have emerged that portray the late Holocene in particular as a period of directed change. This is supported variously by patterns in regional archaeological data. Increases in the density and diversity of lithic artifacts, for example, have been used to argue for greater degrees of sedentism and more intensive occupation, which is considered a response to onset of drier, less predictable ENSO conditions during this period (Smith 1986; Smith and Ross 2008). This is corroborated by continental-scale studies of radiocarbon determinations, which show greater frequencies during the mid to late Holocene (Smith et al. 2008; Johnson and Brook 2011; Williams 2013). From this perspective, human habitation during the late Holocene is viewed in terms of greater investment in local resource extraction and greater degrees of social complexity as groups sought to manage resources for expanding population in an increasingly marginal environment (Williams et al. 2015).

These narratives grew in part from selective use of developments in regional archaeological evidence. Ulm (2013, 184), for instance, critiqued intensification narratives in Australia, arguing that “the limits of archaeological variability, or at least their interpretation, have been predetermined by the expectations deriving from the continental narrative.” This was demonstrated in a tendency within Australian archaeology to focus research attention and chronology building primarily on stratified rockshelters rather than “open sites” and archaeological landscapes (Ulm 2013). Even if rockshelters or other stratified deposits provided higher resolution archaeological data, relying solely on well-preserved rockshelters would necessarily provide a limited window into the diversity of places occupied during the past. As Pettitt (1997, 220) argues, “sophisticated preservation and recovery of archaeology does not necessarily imply a sophistication of behavior that left it there in the first place.”

The dense and the diffuse: evaluating time dependence in accumulation

One of the primary characteristics of stone artifact scatters is the density of artifacts present within them. These can range from diffuse occurrences of isolated stone artifacts to landscapes that are more-or-less blanketed by human modified rock (Foley and Lahr 2015). Artifact density is often invoked in discussions of settlement patterns as an indicator of occupation intensity, where clustering and build-up of artifacts is taken to indicate large gatherings, longer-term stays, more intensive use of space, or some combination of the above (Smith 1987; Williams 1998; Moncel and Rivals 2011; Conard et al. 2012). Given this association, density is often treated as a determinant of heritage significance in the assessment of lithic scatters (e.g. Dallas et al. 1995, 41; Dibden 2012).

The average density of all artifacts on recorded scalds at Rutherfords Creek is 0.58 artifacts/m² (Bryant 2013, 136), with individual densities ranging from 0.03 artifacts/m² to more than 6 artifacts/m². These ranges are consistent with findings in other parts of the region (e.g., Shiner 2004; Holdaway and Fanning 2014), although substantially higher densities are also known to occur. Surveys of lithic landscapes around Olympic Dam near Lake Eyre, for example, have turned up densities up to 100 artifacts/m², leading to estimates of surface assemblage sizes ranging from hundreds of thousands to millions of artifacts (Hughes et al. 2011).

Given that accumulation of material occurs over time, it is expected that more material will accumulate with greater age. However, if density is being used as a function of occupation intensity, then it is possible that this relationship might supersede any time-dependent build-up of material. To examine this relationship, an indicator of assemblage age is needed in addition to its density. Except in a very broad sense (Hiscock 2002), lithic typological markers of chronology are lacking from Australian lithic assemblages. Instead, the ages of heat-retainer hearths were used as a rough indicator of surface age. While it is tempting to presume contemporaneity between hearths and adjacent assemblages, it is entirely possible that artifact accumulation has occurred for longer or shorter time periods than the ages of the hearths. The age of the oldest hearth on a surface, then, represents a *minimum* age for the period of artifact accumulation.

Eight scalds were identified where stone artifact concentrations and dated hearths were recorded in tandem. For the oldest hearths, six were dated using calibrated AMS radiocarbon on charcoal (Holdaway et al. 2010), and two using optically-stimulated luminescence on hearth stones (Rhodes et al. 2010). Mean ages for these hearths ranged from 350 to 1590 BP. Density was calculated using the number of artifacts divided by scald area in square meters. Given non-normal variability artifact densities, these values were transformed logarithmically.

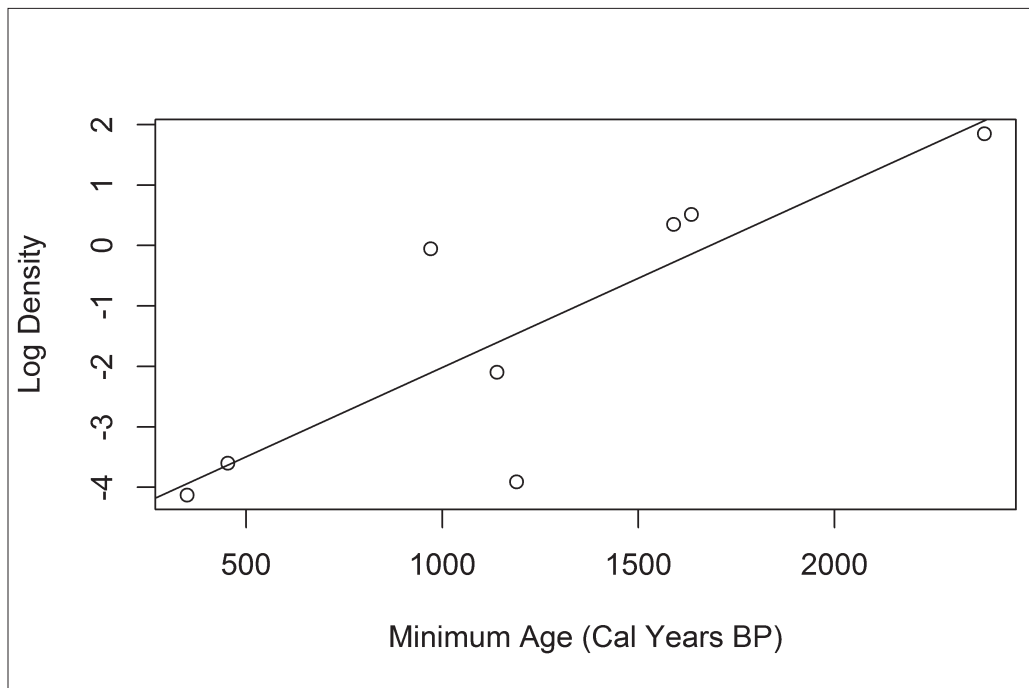


Fig. 4: Linear regression of the minimum age of the scald (given by the chronometric age of the scald's oldest hearth) and the natural log transformed artifact density ($p = 0.00942$, Adjusted $R^2 = 0.6521$).

This is a small subsample of the overall data, but it indicates a relationship between the age of the oldest datable feature and the density of artifacts on scalds (Fig 4; $p = 0.00942$, Adjusted $R^2 = 0.6521$). This correlation suggests that artifact density may be a product of the time that has passed since the surface on which it rests became available for deposition. However, it would be incorrect to assume from this that differential occupation did or did not occur, or even that the time-dependent and behavior-dependent processes that contribute to density are not concomitant.

The challenge of interpreting densities of artifacts is in explaining accumulation. The accumulation of artifacts depends on the amount of time over which the deposit is available to receive discarded material, and the frequency of discard events occurring within that period (Schiffer 1987; Surovell 2009). Schiffer's (1976) well-known "discard equation" allows that if the use-life of an artifact and the number of artifacts in use at any given time can be estimated, then the number of artifacts present in an assemblage can

be used to model the duration of occupation (Schiffer 1976). This model has been shown to be robust, particularly for ceramic assemblages (e.g., Varien and Potter 1997). However, the original formulation of the discard equation assumes that artifact use and discard is constrained to the same vicinity, which is unlikely to hold true for stone artifacts used by residentially mobile groups (Dibble et al. 2017).

Alternative approaches consider the flow of artifacts in and out of a deposit more explicitly. Diversity indices, for example, work under the assumption that places with longer or more intensive occupations are likely to attract a wider range of artifact or raw material types (e.g., Shott 1986; Schiffer 1987; Schlanger 1990). To examine this, artifacts at Rutherfords Creek were divided into groups of unmodified flakes, unmodified cores, unnamed reworked pieces, and formal tool types (e.g., scrapers, pirri points, etc.). These were then compared across scalds based on assemblage density ($n = 93$).

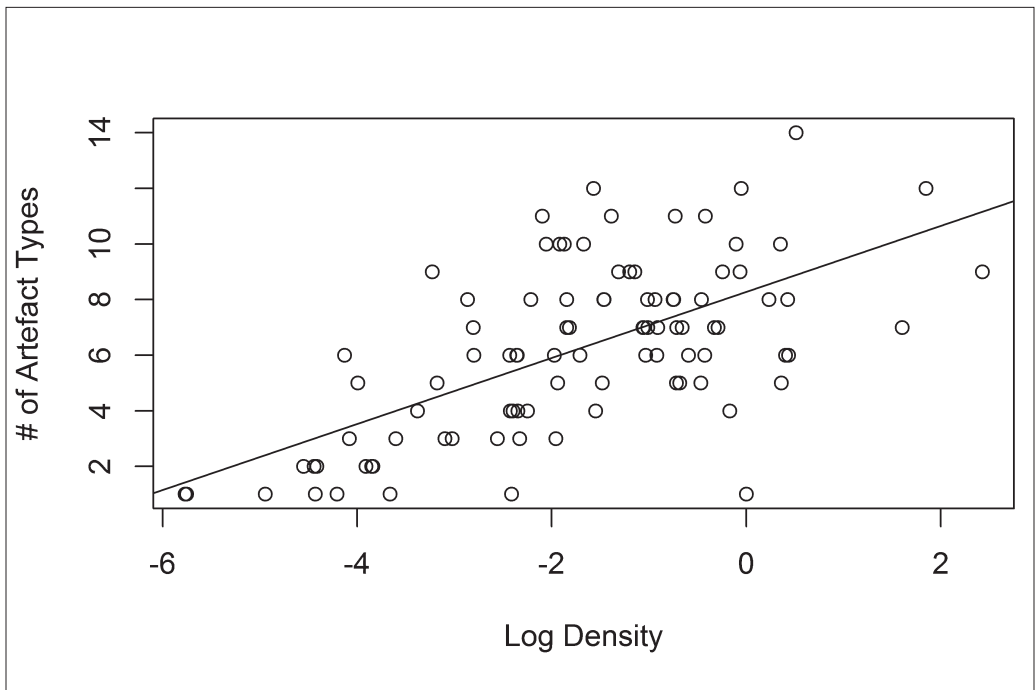


Fig. 5: Linear regression of natural log transformed density and number of artifact types ($p = 0.007$, Adjusted $R^2 = 0.6826$).

The assemblages at Rutherfords Creek show a linear relationship between artifact density and number of artifact types (Fig. 5; $p = 0.007$, Adjusted $R^2 = 0.6826$). This association could indicate the Clarke effect (Schiffer 1987, 55), where more intensive occupation provides more opportunity for rarer artifacts to be included (see also Gould 1977, 168). However, this may also be a product of time dependent accumulation. Assemblages that were available to multiple, unrelated short-term activities attracted a wider variety of discard events through chance (Schlanger 1990).

Another way to consider place use is to consider the extent to which different products of reduction are present or absent. The Cortex Ratio, originally developed by Dibble and colleagues (2005), compares the cortical surface area recorded for an assemblage to that which would be expected for that assemblage. One might imagine an apple, where the peel of the apple is the cortical surface. If the apple is cut up into pieces, the amount of peel on each piece can still be measured, giving the original surface area of the apple. Knowing the average dimensions of an apple, expectations for the surface area of the peel can be estimated. If the amount of peel observed is equal to the amount expected, the ratio is one. If some pieces of apple with peel are added to the assemblage, the ratio increases. Conversely, if there is less peel than the volume of apple would warrant, the ratio value decreases.

The Cortex Ratio is used to show place use by modeling, on average, how much cortical material was moved in or out of an assemblage given estimates of the average dimensions of local raw material and the amount of material present in the assemblage. At Putslaagte, a Middle Stone Age study area in the western Cape area of South Africa, Cortex Ratios lower than one were reported for Middle Stone Age assemblages, indicating the preferential transport away of larger (and thereby cortical) flakes (Lin et al. 2016; see also Parker 2012). In contrast, Lower Paleolithic assemblages at Dealul Guran in south-eastern Romania reported values slightly higher than one, consistent with intermittent removal of non-cortical flaked objects (Doboş and Iovita 2016). The Cortex Ratio can be calculated relatively quickly and without expensive equipment, making it easy to deploy in landscape research contexts.

Cortex Ratios were calculated for silcrete artifacts on 93 scalds at Rutherfords Creek using a method similar to that used by Lin et al. (2016), and then these were plotted against assemblage density and, where available, maximum hearth age.

A statistically significant negative relationship was detected between maximum hearth age and Cortex Ratios for silcrete artifacts, but the regression has little predictive power ($p = 0.01505$, Adjusted $R^2 = 0.05293$). These Cortex Ratios do not demonstrate any substantial shift in the average, which would be caused by imbalances between older/denser and younger/less dense assemblages in the net import/export of cortical materials. Instead, the distribution is highly heteroscedastic. Older/denser assemblages exhibit lower variance in Cortex Ratios, a finding in-line with expectations of the Law of Large Numbers (Fig. 6).

That archaeological deposits obey a well-known statistical principle is not a revolutionary finding, but it is useful to consider what this might mean for discussions of occupation intensity versus accumulation time. If the artifact densities observed at Rutherfords Creek are a genuine reflection of intensity of occupation, as might be suggested from the diversity measures used above, then this is remarkable for its invariance in the overall use of the products of lithic reduction. On the one hand, people who were using lithics more intensively in some places were only doing so at a greater scale than those in less intensive occupations; there is not much difference in the *way* lithics were being used. On the other hand, if assemblage density is only reflecting longer periods of accumulation, then it could be said that there is no obvious spatial patterning in the use of lithic materials within Rutherfords Creek: instead, people who were present inside the

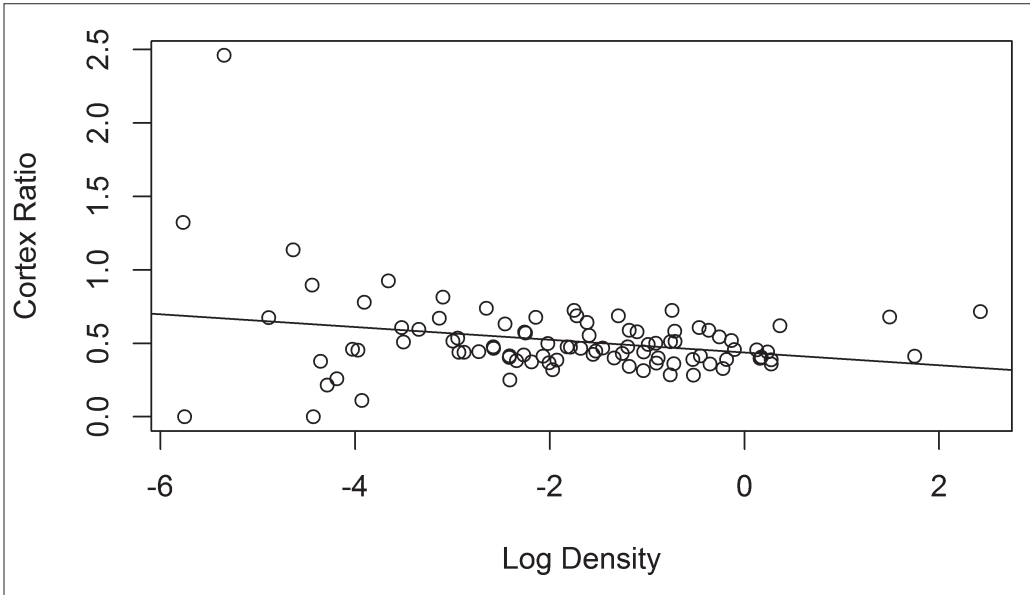


Fig. 6: Linear regression of natural log transformed density and Cortex Ratio ($p = 0.01505$, Adjusted $R^2 = 0.02114$).

time spans represented in the surface assemblages undertook activities related to lithic procurement and discard that were more-or-less consistent across the landscape.

This finding also has implications for the use of density as a criterion determining the significance of surface archaeological assemblages. If the Cortex Ratio outcome of many discard events is, more or less, a product of the cumulative curation strategy over the course of deposit formation, then looking strictly at denser assemblages will indicate a more organized behavioral regime than may have actually existed. The less-dense scatters, by contrast, are far more variable because they are the product of fewer visible discard events (Schlanger 1990). Whether these are the result of a single brief occupation, or an amalgamation of several even more ephemeral discard events, the diffuse scatters help to illustrate how variable the material record of local-scale, short-term behavior can be in archaeological terms. The people at Rutherfords Creek used scalds for a number of different reasons and made use of a range of lithic reduction strategies; but, amalgamated over the longer-term, these exhibit remarkable regularities in place use.

The buried and the remnant: formation as a non-linear process

Critiques over the integrity of surface archaeology stand out against a comparatively uncritical view of subsurface deposits. In a review of the differences between surface and subsurface archaeological deposits, Ebert (1992, 7-14) notes that the recovery of archaeological materials from buried strata can give the impression of being “intact” or “sealed” when their depositional history may only be known superficially (for similar

claims regarding “closed” burial sites; see Olivier 1999). It has been repeatedly noted that nearly all subsurface archaeological deposits were at one time surface deposits (Dunnell and Dancey 1983; Ebert 1992; Wandsnider and Camilli 1992), suggesting that any distinction between surface and subsurface deposits should be qualified not on present depositional contexts but on actual depositional histories (Ulm 2013, 188).

The post-depositional processes affecting archaeological deposits, surface or otherwise, are sometimes described as a linear or superlinear decay, where the probability of survivorship decreases with the age of the deposit (e.g., Marwick 2009; Rubio Campillo et al. 2012). This depiction is not without justification; time-dependent loss is a well-established phenomenon for both natural and cultural materials in geological contexts (Surovell et al. 2009). While this characterization can be justified at a gross scale, it becomes problematic in assessing more localized patterns. The effects of pre- and post-depositional processes do not always operate consistently on all objects, nor do they operate uniformly across time and space (Bettis and Mandel 2002; Allison and Bottjer 2011; Davies et al. 2016).

The condition of archaeological remains is largely influenced by sedimentary history, as net rates of sedimentation and deposition determine whether a deposit is buried or exposed (Waters and Kuehn 1992; Ward and Larcombe 2003; Brantingham et al. 2007). At Rutherfords Creek, intermittent rainfall events are the primary agent of sediment relocation (Fanning et al. 2007, 2009b). Low-energy sheetwash moves loose sediments from some places and deposits them in others, exposing archaeological objects lying near the surface and/or obscuring objects lying on it. Lighter organic materials and smaller clasts (<20 mm) can be moved downslope and be redeposited, while the remaining clasts are lagged on “a mosaic of differently aged surfaces” (Fanning et al. 2007, 284).

In an earlier study, an agent-based model (ABM) called HMODEL was used to understand how widespread but discontinuous erosion and deposition might affect the preservation and visibility of heat-retainer hearths (Davies et al. 2016; Holdaway et al. 2017). ABM is a class of computer simulation in which individual system components (in the form of autonomous computational “agents”) interact with each other and/or their environment according to a given set of rules. These micro-level interactions can generate macro-level regularities over time, allowing the modeler to observe how these larger scale entities emerge. For applications in human behavioral sciences, ABM offer a more explicit abstraction of individual “behavior” than formal mathematical models, offering greater correspondence between model and reality (Kohler 2000; Gilbert 2008; Perry et al. 2016; Timm et al. 2016).

In the model (Fig. 7 and Fig. 8), based on Fanning et al.’s (2007) concept of “episodic disequilibrium”, simulated agents move within a gridded space, constructing hearths at a constant rate, so that the chronometric record generated in the simulation shows no behaviorally-driven change through time. Grid cells contain a set of sedimentary layers, each associated with an age indicating the time when the layer was first laid down, and agents construct new hearths on the topmost layer. At given intervals (in years), an event occurs where affected grid cells undergo one of two processes: erosion or deposition. If erosion occurs, the top layer of sediment erodes, and any hearths situated on that surface lose their charcoal. At the same time, surfaces underneath become visible, including any hearths built on them. If deposition occurs, a layer of sediment is added to the cell,

and any hearths visible on the surface become hidden and thus undetectable in a surface survey. At the end of the simulation, hearths sitting on the surface are “sampled”, and chronological distributions are generated from these samples.

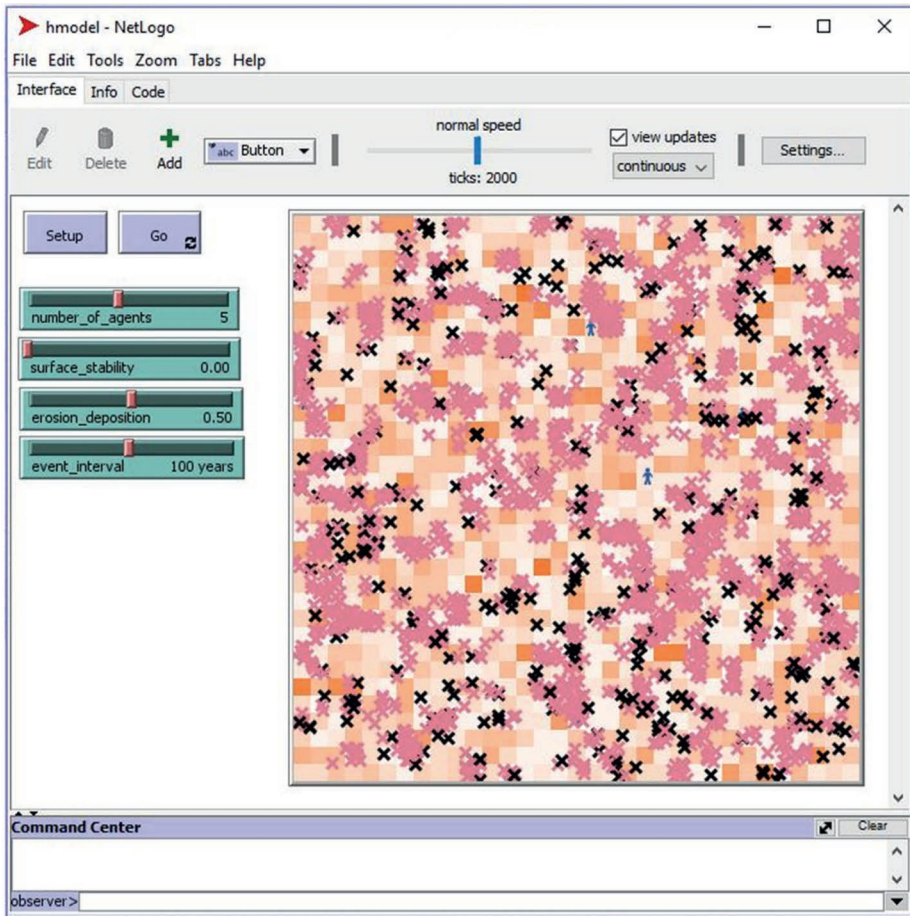


Fig. 7: User interface of HMODEL simulation in NetLogo 6.0. Full color version available online: mgfuopenaccess.org.

The ABM study showed that decreases in the number of hearths with age, as well as periodic gaps in hearth chronologies, may be a product of widespread erosion and deposition across the catchment (Davies et al. 2016). In such a scenario, illustrated in Fig. 9, commonly available sets of surfaces eroding or aggrading during a sedimentary event results in surface features becoming simultaneously invisible, but not destroyed. Starting with an empty surface (top left), hearths are added each year, accumulating at random points across the surface. When a sedimentary event occurs, surfaces will either aggrade (blue) or erode (red), burying any visible hearths or eliminating their charcoal. After this, the process renews, adding a hearth every year but with no hearths from the preceding interval visible on the surface. At the next event, all hearths on the surface

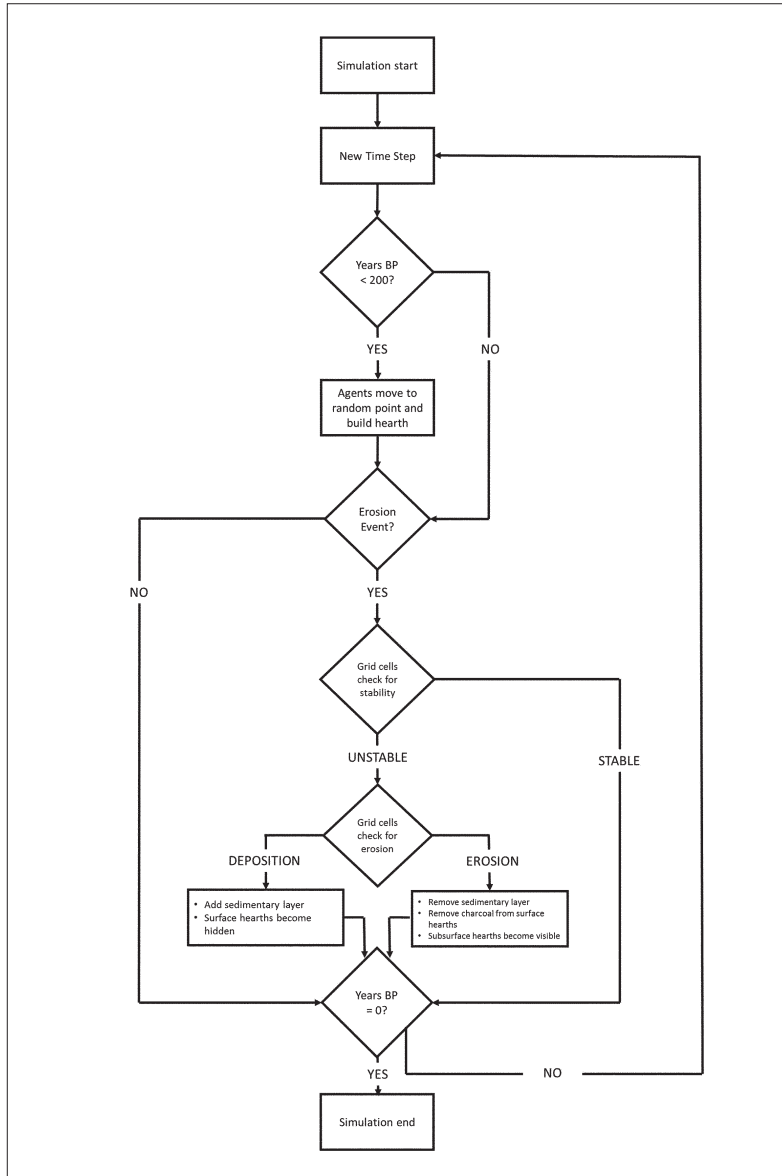


Fig. 8: Flow diagram of HMODEL simulation.

are once again either buried or disintegrated, but hearths that were buried in the previous event on a cell experiencing erosion in the present become visible again. These are visible in much lower quantities than they were at the eve of the preceding event, presenting as a time dependent loss. As time proceeds, a number of new hearths accumulate alongside a handful of hearths from the first interval, but none from the intervening period, presenting as a time dependent loss with a conspicuous chronological gap.

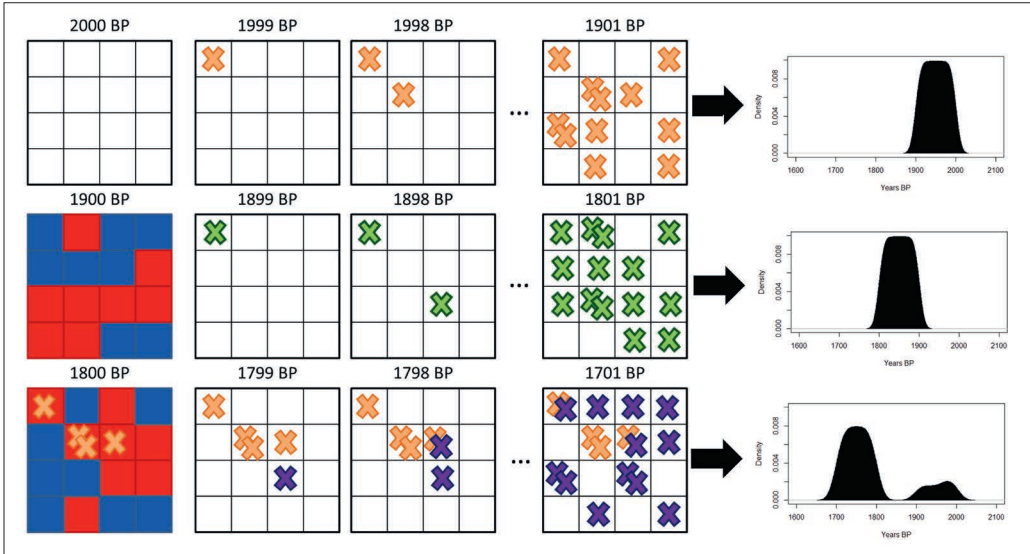


Fig. 9: Process diagram indicating how chronological gaps and decay profile form in HMODEL. Orange, green, and violet crosses indicate hearths constructed during the centuries following sedimentary events at 2000, 1900, and 1800 BP, respectively, while red and blue squares indicate erosion and deposition, respectively. Density plots at right indicate distribution of surface hearth ages at the eve of an erosional event. Full color version available online: mgfuopenaccess.org.

The simulation shows that the process *as modeled* is capable of producing patterning analogous to that found in the archaeological record (e.g. decreasing frequency through time, periodic gaps), the power of the agent-based model lies in its ability to provide an explicit theoretical framework for further interrogation of the record. The systems of interest to archaeologists are often manifold, and are not necessarily indicated by a corroborating signal in a set of data. A single pattern, then, has greater danger of having more than one process which might account for it (Rogers 2000; Beven 2002; Premo 2010). Grimm and colleagues (2005) recommend a “pattern-oriented” approach to modeling, in which a model produces patterning using multiple proxies. These patterns need not be strictly quantitative, as many interpretations of archaeological phenomena are qualitative or impressionistic. However, while a quantitative pattern might be “stronger” than a qualitative one in terms of predictive power, Grimm and Railsback (2012) argue that multiple “weak” patterns might provide for a better approximation of the real-world system than a single quantitative result.

For example, were formation processes like those described by HMODEL operating at Rutherfords Creek, this would have implications not only for the age of surface hearth features recorded in the present, but also their condition. Heat-retainer hearths at Rutherfords Creek are classified in one of six stages of preservation: buried, partially exposed, intact, disturbed, scattered, and remnant. The first three stages describe different degrees of exposure, from completely buried to completely exposed, while the latter three stages describe different degrees of disintegration of hearth stones (for more detailed definitions see Fanning et al. 2009b). Combined, these provide a description of the non-linear life cycle of a heat-retainer hearth.

We can mimic this process in HMODEL by assigning “conditions” to hearths in the different states used in the model. The processes used in HMODEL are an abstraction that simplifies the process into absolutes: buried hearths exposed to erosion become fully exposed, surface hearths exposed to deposition become fully hidden, etc. Therefore, distinctions between different states of burial or disintegration are not nearly as nuanced. However, approximate groupings can be made based on where the categories fit within the model. Three groups used in this study are:

1. Hearths situated under one layer of sediment are considered *buried/partially exposed*.
2. Hearths that are visible but not otherwise affected by erosion are considered *intact/disturbed*.
3. Hearths that are visible and exposed to subsequent erosion are considered *scattered/remnant*.

It is an assumption of the model that, through erosion, hearths will transition from *buried/partially exposed* to *intact/disturbed* and then on to *scattered/remnant*. While in reality it is entirely possible that transitions from the more buried states to the more eroded states might bypass the intermediate stage, given the large proportions of visible, intact hearths at Rutherfords Creek.

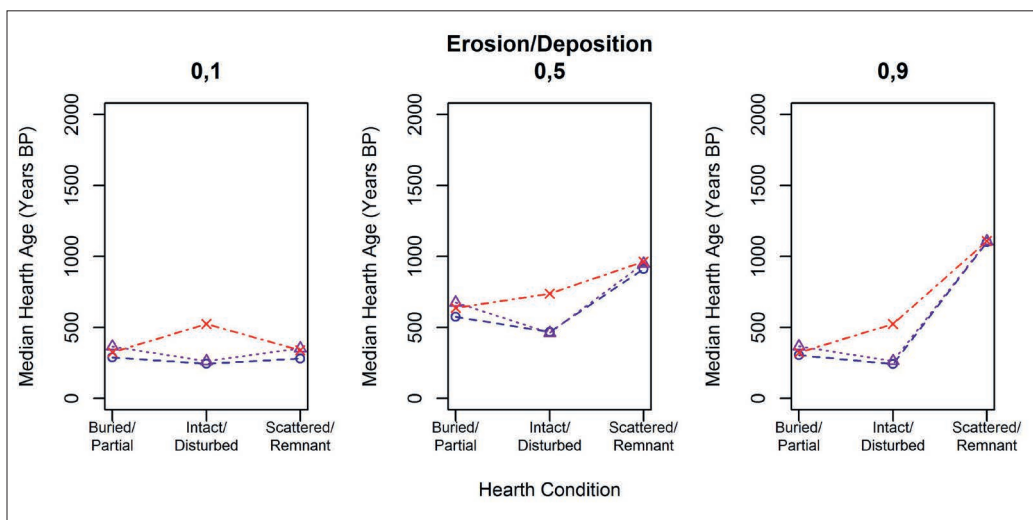


Fig. 10: Simulated effects of differential erosion and deposition on median ages of surface hearths in different preservation categories. Conditions go from deposition dominant (left) to erosion dominant (right). Lines correspond with 50 (blue/circles), 100 (violet/triangles), and 200 (red/crosses) year intervals between sedimentary events. Full color version available online: mgfuopenaccess.org.

The simulation, run 100 times under each configuration of variables, shows a complex relationship between the relative proportions of erosion and deposition, the frequency of sedimentary events, and hearth age (Fig. 10). For shorter time intervals (≤ 100 years), the trend is similar across all erosion/deposition proportions, with hearths in the “buried/partial” and “scattered/remnant” conditions being older on average than those that are “intact/disturbed”. This makes intuitive sense since superposition suggests that those

beneath the surface are likely to be older in general than those on the surface, while those that are scattered are likely exposed for longer and therefore subject to time-dependent decay. Those intact on the surface likely fit into a rare category of being freshly exposed from the topmost layers of sediment. For longer intervals between sedimentary events (200 years), the pattern is somewhat different. The trend in more depositional environments is the opposite of that observed for shorter intervals: hearths that are “intact/disturbed” are noticeably older than those buried or scattered. In this case however, as conditions become more erosional, trends for all time intervals shift as the number of scattered and remnant hearths from earlier periods accumulates with newly scattered examples.

At Rutherfords Creek, the ages of 93 hearths dated using AMS radiocarbon on charcoal were combined into three categories as in the simulation, and the median of these was taken and compared to simulation outputs (Fig. 11). The results show some similarities to the outcomes from simulated depositional environments, particularly those in mixed configurations where erosion and deposition occur in relatively similar proportions. This is true in both the overall age range and the between-group age structure.

The association of this patterning with a mixed depositional environment agrees with the findings from previous studies that discuss the processes contributing to the

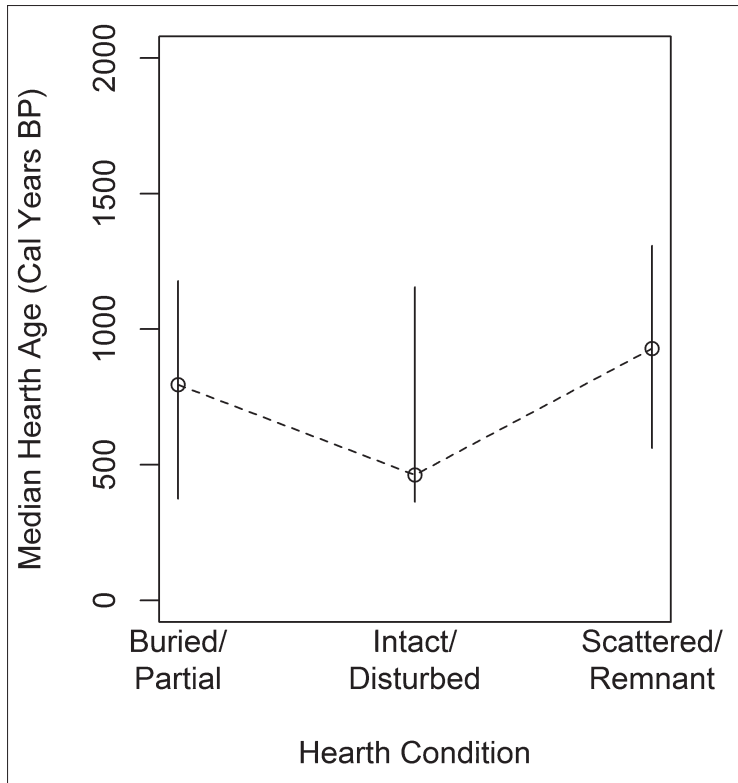


Fig. 11: Median of calibrated ages from hearths at Rutherfords Creek. Bars indicate interquartile range.

exposure (e.g., Fanning et al. 2007, 2009b), and also earlier findings using the HMODEL simulation (e.g., Davies et al. 2016; Holdaway et al. 2017). This suggests that while geomorphic processes are affecting the preservation and visibility of surface archaeological features at Rutherfords Creek, their operation would not be easily characterized as decay. Instead, the fluvial processes that influence the preservation of surface hearths are simultaneously influencing their visibility. But because the process is temporally variable across space (Fanning et al. 2007), the patterning it generates is inconsistent at local, site-level observations, only resolving in aggregate at the landscape scale.

Discussion

Part of unique value of surface archaeological deposits lies in the degrees of visibility they afford. By seeing the extent of the archaeological record normally hidden, Goldberg and MacPhail (2013, 129) refer to exposed surfaces as “windows” through which we can view past landscapes. But when we view the archaeological record through a contemporary behavioral lens, what we see is almost always different from what we hope to find (Binford 1992). In studies of landscape history there is a tradition of ‘reading’ landscapes (Watts 1975; Tilley 1994; Hart 1995; David and Wilson 1999). The metaphor is that the land is inscribed with the collective marks of nature and humanity which, through keen observation, can be read like a text. In a seminal paper on the topic, Lewis (1979) describes a set of guidelines, in the form of “axiomatic” statements, for reading cultural landscapes. These are meant to challenge users to see landscapes not as static representations of a culture’s defining characteristics, but as the outcomes of a sequence of processes, many of which occur at a level such that an individual would be unaware of the consequences at a wider, collective scale (see also Gifford-Gonzalez 1991).

One of these axioms is the *historic axiom*: what has come before will affect what happens later. In archaeological landscapes, the record is generated through a series of processes that are historically contingent, such that what happens at any given time is determined to some extent by what came before, and will influence what happens after. In the case of hearths at Rutherfords Creek, exposure may follow burial, or burial may follow exposure, but the sequence of these events will determine whether a hearth is visible to the archaeologist working at the surface, and what condition it may be in. To establish this, it is necessary to have a theoretical concept of the mechanics of these processes (Lewis calls this the *mechanical corollary*). While an exposed hearth cannot be exposed further in a subsequent event, the erosional forces that cause exposure might alter the arrangement of its constituent parts eventually making it invisible to the archaeologist.

Applying the *axiom of cultural unity and landscape equality* means that if research only focused on the densest assemblages, then the Cortex Ratios values for example would indicate the presence of “extraction sites” or “workshops”, where cortical flakes for export were produced at these places alone. However, when we extend our view to incorporate low-density scatters, it becomes clear that the organization of lithic materials occurred in a similar fashion across much of the landscape. The long-term accumulation that is visible in some places reinforces the idea that this pattern of behavior equally has a long history. Similarly, if a study sought to date only those hearths that are intact, partially exposed, or buried, then it might appear that the hearths are undergoing a process of simple decay over time through exposure. However, by including the more degraded

hearth types, it becomes clear that the forces that control the visibility and preservation of hearths do not act evenly through time and space and the temporal patterns in hearth ages reflect patterns of erosion and deposition.

The landscape equality axiom stands in contrast to many notions of significance embedded in the practices of heritage assessment, despite being partly determined by contemporary scientific values. In a discussion of heritage management of lithic scatters, Versaggi and Hohman (2008) discuss the notion of “context-based” significance, noting that “if small sites with expedient technologies are ignored in the preservation and management process, we create a glaring hole in our interpretations of landscapes and land use.” The view of lithic scatters as unimportant may not necessarily align with the values held by Indigenous Traditional Owners either. For example, Bird and colleagues note that for some Traditional Owner groups, the importance of less visually apparent heritage sites like artifact scatters may lie not as much in their specific informational potential, but in their presence as a regular, tangible connection to country (Bliege Bird 2015). But while awareness of values held by these stakeholder groups is growing, bias against lithic scatters as cultural heritage places is unlikely to abate without collective action (Dortch and Sapienza 2016).

All told, it may be the final *axiom of landscape obscurity* which is most relevant to this discussion of the surface record. This is the idea that while information is encoded in landscapes, the encoding is not likely to be a message that is straightforward or intuitive, but rather one that reflects processes without intended consequence for patterning viewed in the landscapes of the present. The view is encapsulated in the oft-repeated line: “Like books, landscapes *can* be read, but unlike books, they were not *meant* to be read” (Lewis 1979, 13; emphasis in original). To draw out coherent narratives from landscapes, surface or others, focus must broaden to encompass the incorporation process itself: how media and manipulators interacted to produce not a single arrangement of objects, but a succession of patterned outcomes leading to that which is presently observed (Hiscock 1985; Wandsnider 2004).

Considering archaeological patterning as residues, Lucas (2008, 63) introduces the concepts of “reversibility” and “irreversibility”, using the metaphors of book collections (highly reversible) and traffic systems (highly irreversible) to discuss how patterns of material organization which are reinforced and repeated are more likely to persist and be visible over time than those produced by more ephemeral or individualized activities. Activities that do not leave traces that preserve well are unlikely to persist over long time spans, while activities that change frequently in terms of their depositional outcomes are unlikely to leave a discernible pattern. The most persistent patterning, then, would be that which leaves durable material traces and is reinforced through repetition. There are strong similarities between this and Binford’s (1982, 16) notion of “tempo of land use”, and Bailey’s (1983) distinctions between “long-term” and “short-term” scales of behavior.

While variability in the manufacture and discard of stone artifacts is evident at Rutherfords Creek, the overall pattern is remarkable for its consistency in the patterns of flake removal across assemblages of differing densities and corresponding markers of duration/occupation intensity. Assemblages at Rutherfords Creek indicate significant loss of cortical material without evidence for its re-deposition elsewhere within the catchment

or replacement with similar material from elsewhere. The consistency seen in the record at Rutherfords Creek harkens back to interpretations that positioned regular mobility and demographic conservatism as parts of a long-standing adaptation to a desert environment that is by most accounts marginal for human habitation (e.g., Allen 1972; Gould 1977, 1980). These models argued that maintaining mobile, disaggregated populations, particularly during times of resource stress, provided a failsafe against unpredictable shortfalls in local environmental productivity. But environmental unpredictability, along with demographic and social pressures, can create problems that require solving (e.g., David and Lourandos 1998), and solutions that are considered successful may be accompanied by reorganizations of socio-ecological systems. Such state changes often trigger knock-on effects that, in the short term or over the long run, may require additional solutions, creating positive feedbacks within a system (Scheffer 2009, 25; Morton et al. 2011, 325). Social elaborations seen in many parts of the world, such as those observed from the Neolithic period onward, are frequently attributed to these types of feedback systems (e.g. Stiner and Kuhn 2006; Zeder 2009), and the role of such feedbacks is increasingly implicated in Australian prehistory as well (e.g. Smith 2013, 337; Bliege Bird 2015).

An ideal framework for incorporating the variability of patterns of land use would focus on these feedbacks and transitions rather than attempt to fit a single narrative. One such framework is the concept of resilience. Resilience is variably defined but typically refers to the capacity for a system to withstand or adapt to change while maintaining its core functions (Holling 1973). If changes occurred frequently and cyclically, then the record might be expected to settle into a general pattern reflecting this. Feedbacks of substantial amplitudes, like those suggested between population growth, social organization, and environmental productivity as part of intensification narratives, would be expected to shift archaeological patterning directionally given enough time to operate on the record, producing intermediate forms during the earliest stages of this transition. But by this same token, small-scale changes employed strategically to increase overall resilience may leave a more reversible pattern in the wake of the continuity such resilience supports.

These notions interface well with Lucas' (2008) notion of reversibility, which would suggest that different parts of the record would be differently reversible depending on their role in either the maintenance of resilience, or the systemic components which are being retained by that resilience (see also Bailey 1983, 2007). The evidence from the hearths and lithic assemblages suggests a conservative and consistent pattern of hearth creation and the organization of lithic discard behaviors over time that would be difficult to reverse. At the same time, remaining stable and resilient despite high degrees of environmental uncertainty is almost always associated with the capacity for adaptation and change (Redman and Kinzig 2003; Scheffer 2009). However, the magnitude of any behavioral changes that may have occurred at Rutherfords Creek was not sufficient to perceptibly shift the patterning in the selected proxies at their available resolutions (Bailey 1983), which are instead largely determined by accumulation rates and geomorphic processes. It is only when interpretations of the archaeological materials are conceptualized within the context of an ethnographically oriented model that they appear as though they support associations with long term stable aspects of archaeological record (Boyd 2006; Allen et al. 2008; Lucas 2008).

Conclusion

Surface archaeological deposits are characterized by objects which are spatially dispersed and of uncertain temporal association. Archaeologists seek to use patterning in surface deposits to assess the organization of past human activity at the landscape scale, but this is complicated by the formational histories of deposits. An unwillingness to engage with these histories is evident in the branding of surface archaeological deposits as disturbed leading to their exclusion in favor of subsurface deposits. This is compounded by a desire to resolve archaeological deposits at the level of ethnographic description and in terms of sequential short-term behavioral narratives.

A review of the evidence from Rutherfords Creek leads to conclusions run counter to some conventional wisdom but adhere pitch perfect to the Axiom of Landscape Obscurity, that the patterns that preserve and are visible to us may not necessarily be directly informative about all human activities, or even those we wish to know about. Beyond the particular Australian case study, the example has implications for the nature of archaeological inference more generally. A great deal of the pattern seen in the material record may be of the form characterized by Lucas (2008) as irreversible. If so, then the type of shifts inferred from changes in material culture that provide the basis for theoretical approaches as diverse as lithic technological organization, evolutionary ecology, and cultural transmission may need reconsideration. The danger is that by not incorporating formation into these narratives the temptation is to see any patterning in archaeological materials in terms of processes that are relatively familiar to us since they relate to the temporal scale of behavior that surrounds us. In this respect, interrogation of the ethnographic record in search of behavioral regularities will be of little help. Archaeology does indeed provide a window on the past but does not show a vista that reflects the type of processes that we expect to see.

Code and data used in this manuscript can be found at <http://github.com/b-davies/windows-on-the-past-2018>.

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