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## PATTERNS IN THE LANDSCAPE: A CASE STUDY IN NONSITE ARCHAEOLOGY FROM SOUTHWEST QUEENSLAND

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While surface archaeological evidence is increasingly recognised by archaeologists as an important source of information, methods and methodologies to adequately explore the potential of this evidence still require development. This situation applies particularly to arid and semi-arid areas of Australia, which can be characterised by large numbers of artefacts differentially scattered across the land surface. Nonsite archaeology is one approach that has the potential to elucidate patterns of behaviour at a regional scale. Applying this approach, the archaeology of an area around the Currawinya Lakes, southwest Queensland, was surveyed using a stratified, systematic transect sample. Over six thousand artefacts were recorded. Depth of erosion and sand and gibber surfaces were significant factors relating to the presence of artefacts. Patterns of artefact distribution with respect to particular environments could not be established, but the influences of availability of raw material and access a permanent water were clearly recognisable. In addition, a pattern of artefact redistribution was identified, and interpreted as a response to the biased distribution of suitable raw material and water sources across the land surface. By collecting negative evidence and evidence at a regional scale, the results of this survey illustrate the useful role nonsite archaeology can play as an exploratory survey tool. □ *Nonsite archaeology, southwest Queensland, surface archaeology, stratified random sampling.*

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This nonsite archaeological survey undertaken in the vicinity of the Currawinya Lakes, in southwest Queensland, formed part of a larger exploratory regional archaeological study, using a landscape approach. Rossignol (1992: 4) defines the landscape approach as '... the archaeological investigation of past land use by means of a landscape perspective, combined with the conscious incorporation or regional geomorphology, actualistic studies (taphonomy, formation processes, ethnoarchaeology), and marked by ongoing re-evaluation and innovation of concepts method and theory'. In addition to this survey, the study included excavations of rock shelters and open sites, geomorphic investigations and a taphonomic experiment. This research was designed to describe and explain temporal and spatial patterns in the archaeological record (Robins, 1993).

Relatively little is known about the archaeology of southwest Queensland. Until the commencement of this research, only two exploratory excavations had been carried out, and most of the knowledge of the archaeology was derived from observations of surface sites. Archaeological accounts consisted largely of *ad hoc* individual site reports, some dating from as early as the 1920's,

and from the results of Environmental Impact Studies undertaken during the development of the Eromanga Basin oil and gas field over the last two decades, and other minor development, (Robins, 1993, 1995). These records indicate that while different types of Aboriginal sites occur in this area, the predominant form of evidence is large numbers of stone artefacts scattered at varying densities across the land surface (Robins, 1993). For example, in one study at Naccowlah, an area to the northwest of the Currawinya Lakes, Hiscock (1985) reports stone artefact densities for land systems varying from 67/km<sup>2</sup> to 1,932,000/km<sup>2</sup>.

Surface evidence, particularly stone artefact scatters, is often regarded as an inferior source of archaeological evidence due to postdepositional disturbance and mixing that results in a loss of analytical control, especially chronological resolution. However, as Lewarch & O'Brian (1981) point out, occupation deposits in rockshelters and caves are also an amalgam of occupational surfaces that have all undergone postdepositional disturbance. Foley (1981b) argues surface evidence is a product of behaviour and discard, and accumulation and post-depositional processes at a regional scale. The distribution of evidence will

have a structure that reflects these processes. Because the evidence has structure, it also has explanatory potential. There is, therefore, no reason to assume that surface evidence cannot provide information.

Recently, Australian archaeology has seen a variety of research projects focus primarily on surface materials. A number of strategies have been developed to cope either with the perceived shortcomings of surface evidence or to explore ways to elicit patterns in its spatial distribution at varying scales (e.g., Binns & McBryde, 1972; Byrne, 1980; Robins, 1983; Ross, 1984; McNiven, 1985, 1990, 1992; Hiscock, 1987). The increasing importance of cultural resource management, and particularly the implementation of Environmental Impact Studies, has also resulted in increased interest in surface sites and methods of surface site assessment. Few archaeologists in Australia would now argue that surface archaeological material cannot assume archaeological, cultural, political and economic importance. There is still a need, however, to continue to explore ways to demonstrate both the relevance and limitations of surface material, particularly given its ubiquity in semi-arid and arid areas. Consideration therefore needs to be given to identifying and refining appropriate analytical frameworks to use in regional surveys where extensive scatters of stone artefacts are found.

#### NONSITE ARCHAEOLOGY

A common approach used in archaeological studies is to define and identify sites first, and then use them as the basis for subsequent analysis. Sites, therefore, become the focal point for analysis. The concept of the 'site' dominates archaeology and provides the basis for the administrative and interpretive framework for a broad spectrum of archaeological evidence. It has, however, two significant limitations. The first lies in defining and applying the concept of 'site' to archaeological evidence. The second is to account for the sparse, but nevertheless significant, amounts of archaeological evidence distributed across the landscape that are excluded by the application of a particular site concept.

The inherent weakness of the site definition has been recognised for some time by archaeologists, particularly for those concerned with surface sites. Thomas (1975: 63), argues that '... like a pair of worn suspenders, the site concept can be stretched so far that it fails to carry any weight at

all'. Gallant (1986: 408) identifies three classes of site description:

a) The 'benign neglect' approach where site definitions are based on the assumption that a site is a site and no definition is necessary. Thomas & Bettinger (1976: 271) provide a good example of this approach when they state that they relied on experience when they found a site and that they '...recorded an archaeological site whenever we thought one occurred'.

b) The 'correct but vague' approach where the definition is technically correct but, like the worn suspender belt, practically useless. Plog & Hill's (1971: 8) definition of a site as: '... any locus of cultural material, artefacts or facilities', falls within this type.

c) The 'formalised approach', where rigid criteria, usually based on some quantitative or relative measure for recognising sites, are applied.

The last is increasingly used in Australian archaeology, and of the three approaches, offers the greatest utility. It also has limitations, depending on how it is applied and the reasons for its application. If the definition itself is poor, then subsequent interpretation suffers. Measures such as 'a site has to yield at least a double hand-full of cultural material' (Schiffer & House, 1975: 48) are non-replicable and do not form a sound basis for site analysis. To be effective, a relative or quantitative measure must be clearly defined and replicable. Recognising this problem, archaeologists often use measures of discreteness and/or density. Ross (1984: 106) for example, used topographic features to discriminate between sites. Other researchers (e.g. Godwin, 1982; Robins, 1983; McNiven, 1985) have used a standard distance measurement between artefacts or features as the basis for site definition. Where archaeological evidence is common, particularly in arid areas, more comprehensive definitions have been developed. Hiscock (1985: 30) identified sites when the following criteria were met: more than five artefacts;  $2\text{m}^2$  or more in area; average artefact density is more than 4 times the average density of the background scatter; average artefact density of more than  $0.5/\text{m}^2$ .

While the systematic application of clearly defined site recording criteria is an essential first step in the description and analysis of surface sites, the use of such criteria does not overcome a more fundamental problem. This problem is the way in which any such measure is derived and the consequences for subsequent interpretation. Criteria for identifying sites are usually not theoretically derived, but are ad hoc field measurements,

often decided during the initial stages of investigation. The measure of 'siteness', whatever it may be, is usually a subjective measure used solely to delimit the archaeological record to make it analytically manageable or to define areas for subsequent excavation (Dunnell & Dancey, 1983: 271).

If such a subjective measure is then used to infer human behaviour, the problem for subsequent interpretation is that it is driven by subjectively derived criteria that may bear no relationship to the human behaviour that is being interpreted. A halving in values of Hiscock's (1985: 18) criteria, for example, could dramatically increase the number of 'sites'. As Dunnell (1992: 26) notes, '... sites are contemporary and are not *a priori* archaeologically relevant units'. While recognising that limits may have to be set to define the archaeological record, care has to be exercised to ensure that, in the absence of an explicit theoretical basis, subsequent interpretation is not unduly influenced by an artificially derived site definition (Robins, 1983).

The application of rigid definitions in areas where the environment is highly mobile, such as dunefields and sandplains, may be inappropriate on other grounds. It is possible in these circumstances for sites to turn to background scatters and back to sites in a few months, depending on the site definition and the exposure of archaeological material at the time (Robins, 1983; Balme, 1991; McNiven, this volume). Such cases emphasise that sites are not depositional units and there is no necessary link between artefact scatters and ethnographic concepts (Dunnell, 1992).

Some archaeologists have found the site concept limiting. Site definitions can exclude large bodies of archaeological evidence that fall outside of the definition used. The concept is not seen as useful in certain cases and the use of sites, particularly excavation sites, can produce a biased and bounded archaeological perspective. Dunnell & Dancy (1983: 268) argue that, at a regional scale, use of the site concept may even obscure information.

To accommodate these circumstances, a number of terms such as 'background scatter', 'background noise', 'siteless survey', 'off-site archaeology', 'antisite archaeology', 'distributional archaeology' and 'nonsite archaeology' have been created (Thomas, 1979; Foley, 1981a, 1981b; Dunnell & Dancey, 1983; Gallant, 1986; Bintliff & Snodgrass, 1988; Ebert, 1992). There are, however, no accepted definitions of these

terms and the 'off-site' approach (Foley, 1981a) has similarities to the 'nonsite' approach (Thomas, 1979). For this research 'off-site archaeology' describes strategies used to account for archaeological material that falls outside the site definition (background scatter) when a site definition is used. The term 'nonsite archaeology' is used to describe strategies that interpret archaeological material without reference to the site concept.

One way to overcome the deficiencies inherent in the site approach is to record the distribution of archaeological material first, and to identify sites, if necessary, on the basis of the results of the survey. The archaeological evidence can then be treated as a continuum ranging from a single artefact to high density scatters (Gallant, 1986: 409). Where sites will be on this continuum can then be determined in an explicit way after consideration of all evidence and in accordance with research aims. The alternative approach is to ignore the concept of the site altogether. If either of these is adopted, the artefact or the cultural item, not the site, becomes the minimal unit of analysis (Thomas, 1975: 62).

The term 'nonsite archaeology' was introduced by Thomas (1975) while undertaking the Reese River Ecological Project to test archaeological models based on Julian Steward's ethnography of the Great Basin Shoshonean Indians (Thomas, 1973). A computer simulation of settlement and subsistence was developed and a number of archaeological consequences predicted. These were expressed in terms of artefact assemblages; butchering, hunting, plant procurement and habitation. The predictions were then tested through the implementation of a random sample. The results of the sample were then compared to the predictions (Thomas, 1973). The research design for this project did not require the concept of 'site', because the predicted consequences were in terms of the distribution of cultural items. Thomas notes, however, that he also located, recorded and collected sites in the traditional manner (Thomas, 1975: 81). The methodology Thomas adopted has limited application in the context of this research as it was based on a detailed ethnographic account, information that is absent for southwest Queensland.

While other studies that have adopted a nonsite approach (for example; Bettinger, 1977; Bintliff & Snodgrass, 1988; Dunnell & Dancey, 1983; Gallant, 1986; Jones et al., 1989), work that has most utility for the present study is that of Foley (1978, 1981a, 1981b, 1981c). This was con-

ducted in the Amboseli, Southern Kenya. Foley sought to develop appropriate theories and methodologies for archaeological interpretation at a regional scale that were applicable to small-scale, mobile societies using lithic technologies.

Using the ecologically derived concept of home-range developed by Wilson (1975), Foley argues that the model for study of regional subsistence behaviour should be based on the concepts that :

- 1) The structure of human subsistence behaviour is spatially continuous;
- 2) The spatial organisation of that behaviour is largely home-range-specific;
- 3) The structure of the home-range will reflect the non-uniformity of resource distribution across the landscape, in relation to human adaptive strategy;
- 4) It may be expected that the material aspects of adaptive strategy and hence discard, will reflect these ecologically controlled patterns; and,
- 5) The regional archaeological structure will be spatially continuous. It will reflect the differential distribution of resources and the deployment of the home-range as a means of utilising those resources (Foley, 1981a: 13).

Interpretation of the regional archaeological structure demands consideration of:

*Behaviour and discard.* Within the home-range, human activity would be continuous but variable. It follows that the material discard that results from variable behaviour within the home-range should be patterned in a way that reflects that behaviour. Five basic spatial components account for all subsistence-based discard. These include: the home base, the home base periphery, the secondary home-range foci, the occasional home-range loci and extra home-range loci. Home-range behaviour and discard can vary and co-vary with ecological factors including topography, productivity, climate, habitat and diet and subsistence strategy. Distortions in the pattern are due to a lack of correlation between discard and behaviour and variations in technologies and subsistence strategies.

*Accumulation.* The continued accumulation of archaeological material from discard over long periods is considerable. Using ethnographic data Foley (1981b: 11) estimated that over a 100 year period a single band could use and discard 16 million artefacts at a density of 52,000/km<sup>2</sup>. This accumulation can undergo blurring and distortion through different activities in the same place or shifts in resource distribution and subsistence strategies. The chronological resolution of sur-

face material remains a problem, but it is suggested that superior spatial information for relatively large areas is at least as important as a chronology obtained from a few sites.

*Post deposition.* Discard patterns are 'filtered' by post depositional burial, erosion, movement, complexity and destruction.

This framework provides the underlying structure for interpreting regional artefact density variability. To undertake such an interpretation it is necessary to provide a surface artefact density map that can be interpreted in terms of ecological and taphonomic parameters.

To do this, Foley argued, research must be undertaken on a scale that encompasses more than one home-range to allow for inter- and intra-home-range variability (Foley, 1981b). The size will be variable, but an area of 1,000km<sup>2</sup> is suggested for tropical regions. It should be defined on the basis of regional ecology. Archaeological surveys of such regions should employ a sampling strategy in which all points on the surface are treated equally and use techniques that can document the behavioural, accumulation and post-depositional influences. Areas with and without artefacts should be treated as equally significant.

In the case of the Amboseli, Foley found that the archaeological record is continuous and that low density distributions of artefacts can be informative. A mean density of 19,000 artefacts/km<sup>2</sup> was recorded although this was not uniformly-distributed. This implied some structure could be partly accounted for in terms of taphonomy and behaviour. Importantly, Foley's model was aimed at a gross scale of human behaviour operating over long periods. (Foley, 1981a).

In assessing the results of the Amboseli work Foley (1981a: 198-199) observed several limitations of his approach: the low sensitivity of an ecological approach; lack of chronological resolution; bias due to aggrading land surfaces; and probable limitation to arid and semi-arid landscapes. In view of its potential, however, it seems useful to develop his methodology further and examine its value in arid Australia.

The Currawinya Lakes study area, with its arid climate, topographic and environmental diversity, and variable distribution of potable water and flakeable stone, provides the requirements to effectively test a nonsite approach.

The explanatory potential of surface evidence for this study was enhanced by evidence obtained

from a complementary dating program. Excavations in one rockshelter, eleven open sites, and reconnaissance geomorphic work within the study area provided a temporal framework within which surface evidence could be placed. Although there is evidence of at least 13,000 years of Aboriginal occupation (Robins, this volume), apart from artefacts cemented in hardpan, all the dated surface evidence is younger than 2,000 years (Robins, 1993, 1995, 1996). This evidence is consistent with geomorphic models of landscape development (Jessup, 1960a, 1960b, 1960c, 1960d, 1961; Hallsworth et al., 1984) and confirms the assumptions of previous workers about the temporal relationship between the archaeological evidence and the land surface that it is on (Hughes & Lampert, 1980; Hiscock, 1985; Williams, 1988).

In keeping with an exploratory approach, this study investigated a range of working hypotheses that examined behavioural and non-behavioural factors. This is a coarse-grained strategy. It was designed to describe and explain aspects of the archaeology of the study area at a basic level, and hypotheses attempt to detect patterns at a gross scale only.

#### THE STUDY AREA

The study area falls within Currawinya National Park and Kilcowera Station, and is approximately 655km<sup>2</sup> in area. Its centre lies at 28°45'S latitude and 144°15'W longitude and falls within the Paroo Plains of the Central Lowlands Province identified by Jennings & Mabbitt (1986) and the Murray - Darling Plains identified by Butler et al. (1983). These classifications emphasise the geographic links the study area has with the Murray Darling Basin.

The study area is situated on the eastern edge of the arid zone (Winkworth & Thomas 1974: 3). The climate is Arid (mainly summer rain) - Subtropical with hot to extreme, very dry summers and mild to warm, dry winters (Bureau of Meteorology, 1989).

The topography is characterised by low altitude and low relief. The maximum altitude is at Mt. Roy (231m ASL) and the minimum in Lake Wyara (119m ASL). Local relief throughout the sandplain rarely exceeds 5m. In the dissected residuals the topography is rugged and local relief is greater, although it rarely exceeds 20m. The dominant features of the landscape are the lakes Wyara and Numalla (Fig. 1). These are located approximately 30km NW of the QLD/NSW bor-

der town of Hungerford. The anastomosing channels of the Paroo R. are approximately 5km to the southeast of the eastern boundary (Fig. 1). The lakes are situated on the extreme northwestern margin of the Murray-Darling Basin. Lake Numalla both feeds, and is fed by, the Paroo R. system which in turn flows into the Darling R. 200km to the south. It rarely dries. Lake Wyara, a shallow, ephemeral, saline lake is the sink for a small internal drainage system. Although it frequently dries, it is a major nesting site for pelicans and swans, and at times harbours high numbers and diversity of birds. Springs and small ground-water soaks also occur throughout (See Robins, this volume).

Surrounding L. Numalla and abutting L. Wyara on its western, southern and northern margins are extensive, low relief sandplains graduating to hard and soft mulga lands. Dissected residuals with steep escarpments flanked by low hills and stony plains, dominate the topography to the west of L. Wyara. An extension of this ridge protrudes into the sandplain to the south of both lakes. Around the eastern margin of this low ridge, a chain of small ephemeral lakes have formed in the sandplain (Fig. 1). A summary of land systems within the study area is presented in Appendix 1.

Two environmental studies (Stanton & Morgan, 1977; Purdey, 1985) indicate that this area is highly representative of the Mulga Lands of southwest Queensland.

Assessment of the logistical and geographical problems involved in surveying this area given the time, resources and financial constraints, indicated a maximum study area size of approximately 700km<sup>2</sup>. Its shape was determined by: a desire to include the maximum environmental diversity possible but at the same time to incorporate replicate land systems; to have both erosional and depositional environments; to contain the study to areas within the catchment of the lakes to enable better control of environmental factors, and to keep within well defined boundaries of two properties to minimise navigational and logistical difficulties. The northeastern boundary was formed by the Hungerford-Thargomindah road, the northern boundary by the property boundary between Currawinya and Boorara stations and between Kilcowera and Budgheree Stations, and the western boundary by the watershed between the Lake Wyara and Cardenyabba Ck. The western portion of the southern boundary is defined by the boundary between Karto, Kilcowera and Currawinya Stations. The eastern portion

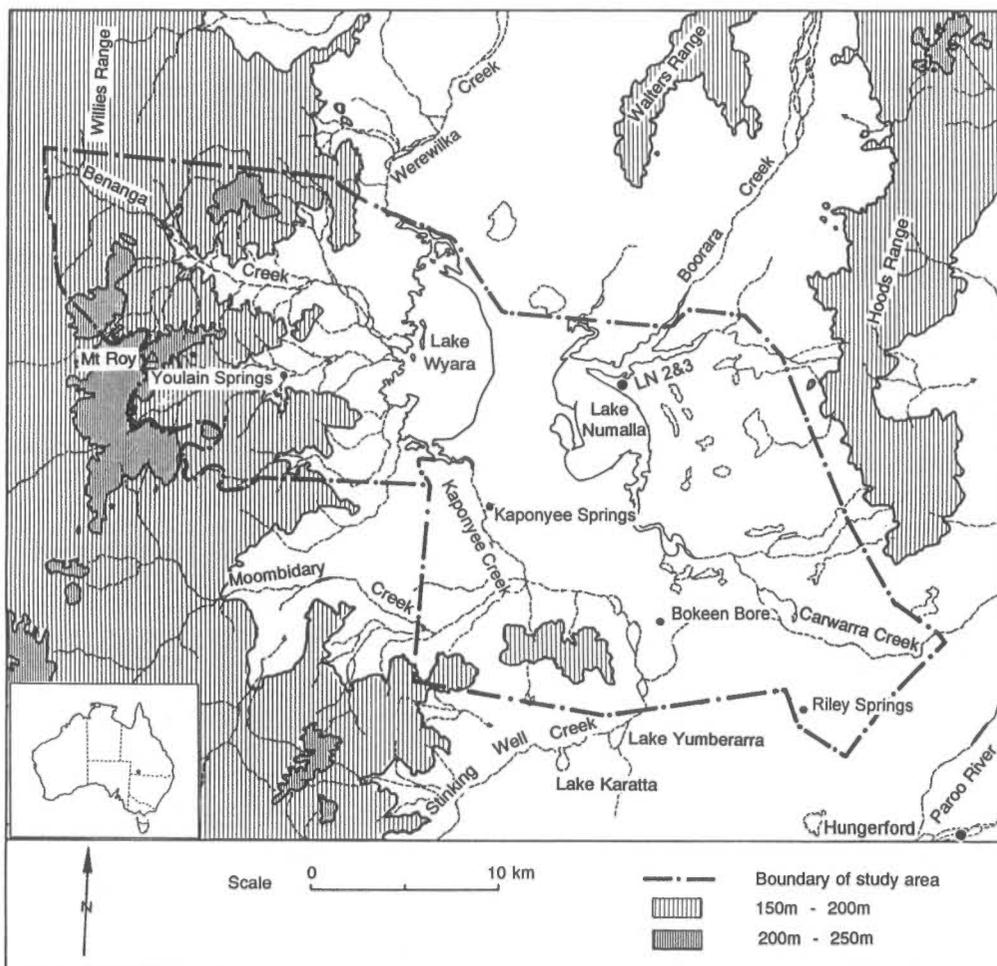


FIG. 1. Location of the study area.

of the southern boundary is defined by a series of internal fence lines within Currawinya. The Hungerford-Eulo road forms the short eastern boundary (Fig. 1).

#### NONSITE SURVEY

A reconnaissance survey, comprising 125km of transects and selected site examination, was undertaken to confirm observations of the archaeological record derived from other regional research and personal observation, and to define the basic character of the archaeological evidence of the study area. The survey recorded large numbers of stone artefacts differentially distributed

across the landscape (Figs 3a-c). Artefacts occurred in five broad patterns, and large numbers were associated with permanent water sources. This information assisted in the design of the nonsite survey, including the formulation of hypotheses. The results are described in Appendix 2.

The implementation of a nonsite archaeological strategy requires the execution of a probability sampling strategy. Although probability sampling is a tool that has been commonly used by archaeologists over the last two decades (Binford, 1972: 135-160; Redman, 1974; Plog et al., 1978; Read, 1979; Dancy, 1981; Dunnell & Dancy, 1983; Shennan, 1990; Renfrew & Bahn,

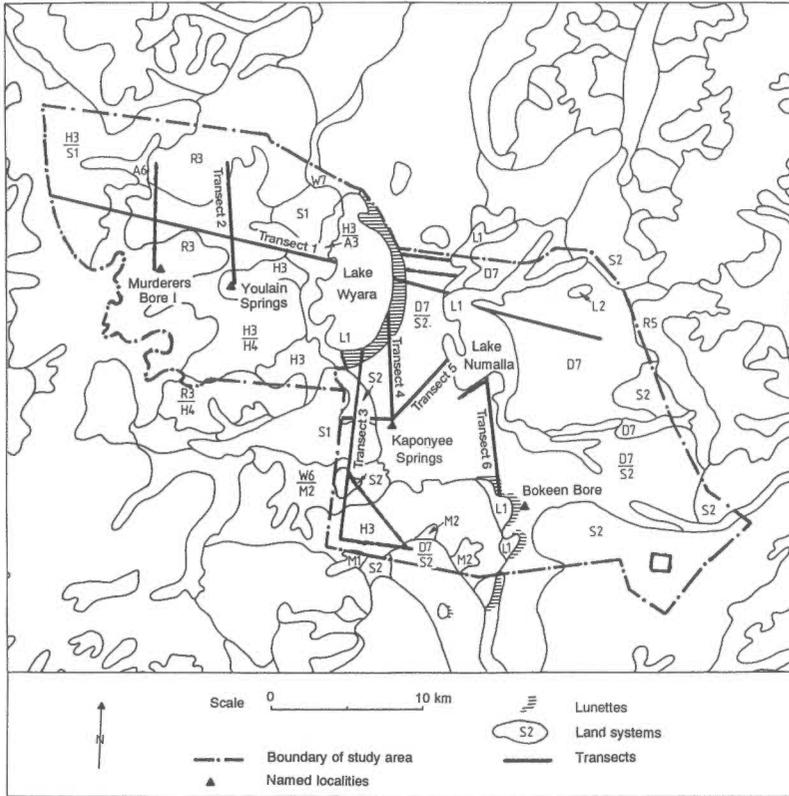


FIG. 2. Transects and sites selected for the reconnaissance survey.

1991), it has not gained favour in Australian archaeology, where few such surveys have been conducted (Attenbrow, 1987).

The aim of probability sampling is '... to draw a sample which is an 'honest' representation of the population and which leads to estimates of population characteristics with as great a precision as we can reasonably expect for the cost or effort expended' (Shennan, 1990: 299).

Redman (1974: 3) argues that the advantages of sampling over complete coverage are reduced costs, greater speed and greater scope of coverage. Such advantages cannot be ignored when rapid evaluation of the archaeology of an area is needed. Sampling is a flexible tool and the choice of a sampling strategy will be determined by a number of case specific circumstances of a theoretical and practical nature. There is no standard sample design (Redman, 1974: 3). However, when designing a sampling strategy, the following should be considered: shape and size of the sample unit; the fraction of the sample; stratifica-

tion of the sample; the target population; and intensity of the survey (Redman, 1974; Plog et al., 1978; Judge et al., 1979; Read, 1979; Attenbrow, 1987: 68).

Sampling also requires careful planning (Redman, 1974), including realistic evaluation of problems with field survey. Time and resources must be budgeted with a balance between time spent locating a sample unit, and time spent surveying it (Plog et al., 1978: 395). Several random sampling schemes have been initiated, only to be abandoned due to difficulty of implementing the schemes as planned (Smith, 1980; Lilley, 1982). Foley (1978: 60) argues that it is better to start with a small, attainable sample that can be expanded into a second stage, than to

start with an ambitious sample that has to be reduced or abandoned at a later stage.

In addition to these considerations, the sampling strategy had to be easily implemented in rugged, isolated and poorly mapped terrain, safe, and satisfy budget constraints.

As the study area was situated in a remote region, the survey method had to minimise risks to inexperienced field workers. Work parties had to be easily monitored. Given the field conditions, and on the basis of the results of the reconnaissance survey, transects were assessed to be the safest and most efficient organisational method to conduct the survey.

In this case a budget of a single field season of 600 person hours, or approximately six weeks for a two-person survey team, was allocated. It was estimated that in this amount of time, 1% of the study area could be systematically traversed with a smaller amount surveyed in detail.

During the reconnaissance survey the time taken to record the number of artefacts in the



(Plog et al., 1978: 389). Small survey units can be intensively surveyed and uniformity of data collection guaranteed. Foley's experiments (1978) indicate there is greater observer error in large sample units than in small sample units. In addition, small units maximise the number of points sampled for a given sample fraction, and are thus more efficient (Redman, 1974: 19, Plog et al., 1978: 401, Read, 1979: 51).

In regional surveys, practical considerations commonly temper the theoretical requirements of the sample design. Evidence of this compromise is reflected in the small sample size of many regional surveys (Foley, 1978, Wobst, 1983). Foley (1978: 59) points out that the size of a sample is to some extent dependent on the nature of the questions being asked. Where large populations of artefacts, as opposed to sites, are the basis of regional surveys, there is no practical way of obtaining a large sample size because of the sheer number of artefacts. In these instances Foley (1978: 59) argues that it is the relationship between the size of the unit and the size of the 'data component', and not sample size, that is crucial in the selection of a sampling strategy.

In many cases other practical considerations, particularly finance and labour, determine sample size. Under these circumstances, sample size becomes a moot point. Provided the sample is efficient and effective, similar amounts of data can be obtained from probability surveys as from non probability surveys.

The hypotheses presented for testing during this survey all relied to some degree on the environment. To ensure equal representation of all major environments throughout the study area, the sample was stratified according to land system. The sampling system that best suited the theoretical and pragmatic selection criteria was a stratified systematic transect sample (Redman, 1974: 17).

METHODS

The study area was divided into two sub units:

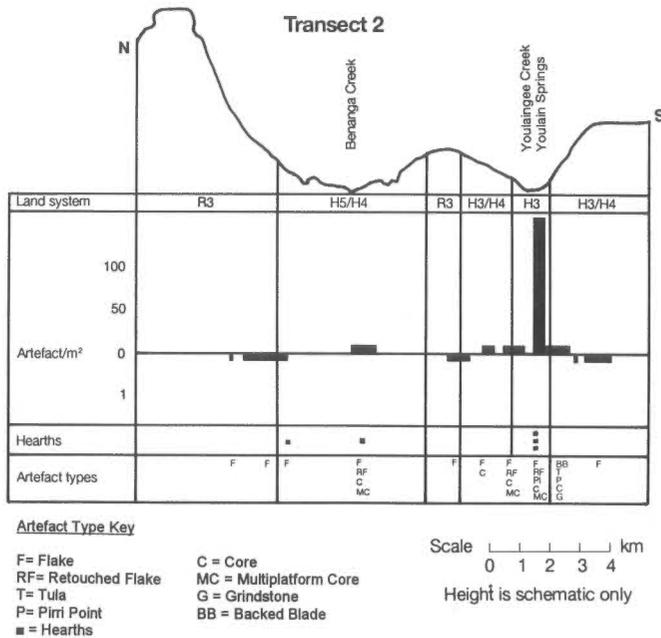


FIG. 3b. Reconnaissance transect 2.

areas A and B. Area A (232km<sup>2</sup>) included all the study area in Kilcowera Station and area B (436km<sup>2</sup>) all the study area in Currawinya Station. This partition roughly coincided with the two major physiographic units in the study area; the sandplains and dunefields in the east and the dissected residuals and associated land systems in the west. This division allowed for variations in treatment during fieldwork or data analysis.

Each of the land systems was given a unique number, and a base map with all the land systems was prepared (Fig. 4). A grid was then superimposed over this map and the area of each land system calculated. When many of the fence lines in the study area had been constructed they had been aligned with, or at right angles to, magnetic north. These provided excellent field reference points. Two east-west baselines, one each for areas A and B, were established along fence lines that ran through the approximate centre of each area. These were then divided into a series of 50m wide transects that intersected the baseline at right

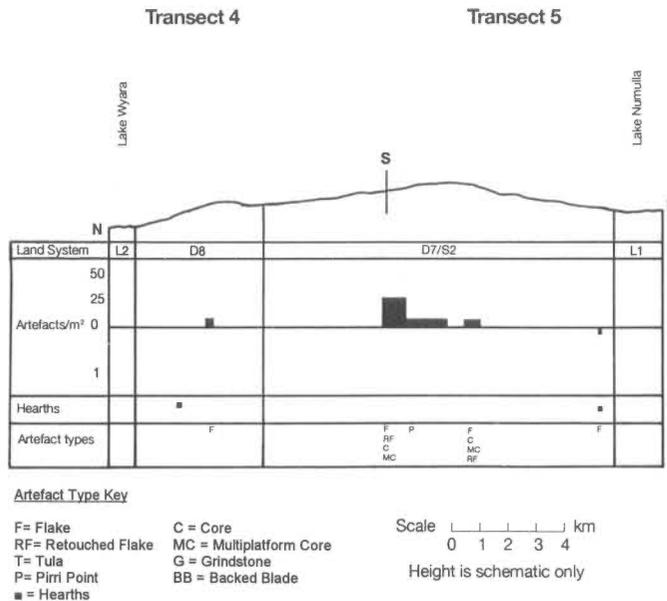


FIG. 3c. Reconnaissance transect 4 and 5.

angles. Fifty metres was considered to be the minimum width that could be identified in the field with an odometer or with reference to features on aerial photographs. Area A had a baseline of 22.5km and area B a baseline of 27.5km. This translated into 450 and 550 transects respectively. Each of these transects was consecutively numbered. The survey transects were then selected from these using a random number table (Zehna, 1974: 399).

The length of sample transect for each land system was determined by calculating the length of 50m transect necessary to make up 1% of the area of that land system. The first transect number selected from the random number table was superimposed on the base map and the length of transect for all those land systems it crossed calculated. If the selected transect had insufficient distance to make up the 1%, more transects were selected from the random number table until the quota had been made up.

All the transect distances were calculated from the baseline. Distances for all transects that commenced south of the baseline were calculated from the northern boundary and all those that commenced north of the baseline started on the southern boundary. Where the baseline fell within the land system all calculations were made from it. This was necessary because boundaries of land systems are not always clearly identifiable. To ensure that sampling was being conducted in the correct land system, quadrat sampling commenced between 100m and 250m inside the estimated land system boundary, depending on the size of the land system.

In all, 132km of transect was planned; 46km for area A and 86km for area B (Fig. 4, Table 1). Although the minor lakes, and occasionally the major lakes can dry, at the time of survey all had water in them, making examination impractical (sample units 31-35). Cawarra Ck was in flood at the time of survey and land system 30 could not be surveyed. Land system 2, in the northwestern section of area A proved too difficult to get access to. In all, 28 of the 35 systems were surveyed. This reduced the sample area to 585km<sup>2</sup>, or 87% of the total study area. The length of transects were commensurably reduced to a total of 116km.

The identified transects were then used as corridors within which sampling took place. The relevant sample corridor was identified by following along the baseline from a predetermined point the required distance and then heading along the transect at a compass bearing of 5°N or 185°S. Prominent landmarks that could be identified on aerial photographs such as roads, huts, bores and natural features were also used to determine the position of transects.

At set intervals along each transect (250m for area A and 200m for area B), 20m x 20m quadrats were laid out and the required data gathered. A minimum of two quadrats were surveyed for each land system; one at the start of the transect and one at the end. Generally, area A was considerably rougher than area B, with numerous escarp-

ments, steep gullies and creeks and irregular and rocky surfaces. To compensate for the additional field distance, as opposed to plan distance, travelled in area A, quadrats were placed at 250m intervals. Using this method, it was expected that 537 quadrats would be surveyed; 184 in area A and 353 in area B.

The data collected for each quadrat was recorded on a quadrat data sheet in A5 pads for field convenience (Robins, 1993: Appendix 1). This data sheet contained 35 fields of information that noted the location of the quadrat; its environmental context and relationship to key elements in the landscape; factors that effected both the recording and condition of the quadrat; and data about the artefacts. If no artefacts were in the quadrat then only the first 22 fields were used. In addition, a simple checklist designed for the rapid recording of data about the number, size, class, type and raw material of artefacts found in the quadrat, was used (Robins, 1993: Appendix 1).

A decision was made at the outset of the survey that no artefact collection would be made, as this would unduly slow the recording and it was not necessary given the coarse grained nature of the study. Artefacts were recorded using a checklist of artefact types based on the results of the reconnaissance survey. This list was then expanded to cater for size classes and raw material types. Using this method, 97 artefact classes were identified (Robins, 1993: Appendix 2). There was provision on the form to record additional types. To aid identification, a basic description of artefact types was drawn up (Robins, 1995: 666). This data was then collated and put on a database (Minark 4.1) for analysis.

Implementation errors occur when field circumstances influence the collection of data. Control of these errors was kept to a minimum by ensuring that all participants in the survey operated by the same rules. Rules and conventions were established to ensure that the correct land system was sampled and that environmental data was recorded in a consistent manner. All artefacts were identified according to the same criteria and whenever possible, checks were carried out to ensure that these were adhered to. If there was any doubt with identification, an item was not recorded as an artefact (the 'if in doubt chuck it out' rule was applied). In addition, the leaders of all survey teams were graduates experienced in artefact identification. This was an important consideration due to the difficulty of identifying many artefacts made on silcrete (Hiscock, 1985). The recording method was kept simple and only basic

information recorded. This method restricted the amount of detailed information collected. However, it recognises the limitations of collecting data in the field, particularly in circumstances where even simple identification procedures, such as double checks or microscopic examination of borderline specimens, are not usually carried out.

The data set derived from this survey offers considerable potential to explore a broad range of questions in some detail. It is possible, for example to, examine the relationship of one artefact type to other artefact types or environmental factors in some detail. However, as the hypotheses only address general issues with the aim of identifying structures in the distribution of archaeological evidence at a landscape scale, the data was explored in a general way only.

Conventional site surveys are not usually structured to collect negative evidence. Without this evidence however, it is often not possible to demonstrate an effect (Thomas, 1979). A nonsite survey strategy, on the other hand, allows the collection of negative evidence. The relationship between positive and negative evidence is explored, in the first instance through the use of histograms. Further clarification, when required, was obtained through the use of chi-squared tests for  $r \times c$  contingency tables. Other questions are explored through the use of graphs. Exploratory analysis of more complex relationships was undertaken using a range of non-parametric statistical methods including Spearman's rank correlation coefficient and the Wilcoxon rank sums test in order to test the significance of differences found. Logistic regression was used to identify predictive features where the data was dichotomised as being Type A or not, Type B or not and so on. Diversity was characterised using the Shannon-Wiener and Brillouin indices. Analyses were performed using the SAS statistical package. Although the design of this survey was based on random transects of 1% of the total landsurface, only 0.04% was surveyed in detail. This survey took approximately 550 person hours to complete at an average of 1.05 hours to locate and record each quadrat. Considering the nature of the country and the numbers of artefacts recognised during the survey, this method was cost effective.

One of the problems with the survey method was that it was incremental - the location of one quadrat is dependent on the location of the previous one. In a rugged and poorly mapped area, checks on location are difficult to apply. Naviga-

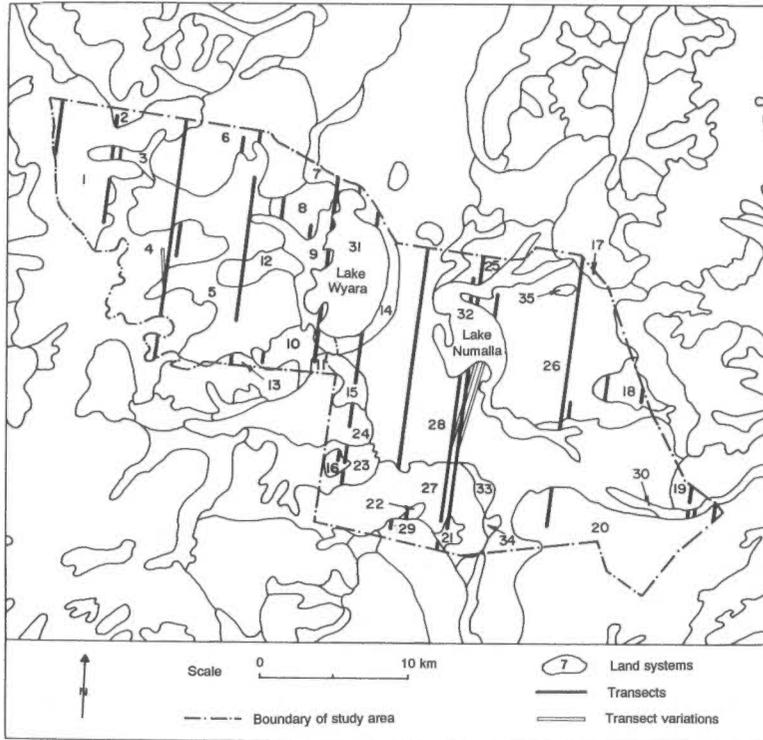


FIG. 4. Stratified transect sample, with surveyed variations.

tional errors in both angle and distance measurements can result in failure to record quadrats that should have been recorded and the recording of ones that should not have been. During this survey, only three transects (4, 15 and 16) veered significantly off course along sections of their length (Fig. 4). However, as the recorders assumed that they were on course and did not realise the mistake until the end of that section, this is not a deliberate error and will not effect the randomness of the survey. Given the survey conditions and the crude method of navigation, the accuracy in placement of the transects was surprisingly good.

Variations in the length of transect and consequently number of quadrats, were more frequent. The variance between the total expected distance and the surveyed distance was 3km (116km to 113km) or 2.4% (Table 1). For Area A the variance was 4.6% while for Area B it was less than 1%. There was a reasonable correlation between the variation in distance and the number of quad-

rats recorded. There were twelve fewer quadrats recorded than expected, an overall variance of 2.2%. In Area A there were eight (4.4%) fewer quadrats recorded than expected while for Area B there were four (1.1%). The greater error in both the distance and overall quadrat recording for Area A can be attributed to the more rugged terrain and the difficult survey conditions. Twenty-one percent of land systems had more than the expected number of quadrats and 39% had less. The high percentage of quadrats with fewer than expected quadrats can, in part, be attributed to the desire of recorders to ensure that survey commenced within the boundaries of the designated land system.

Seventy nine percent of the land systems fell within  $\pm 2$  quadrats of the expected, indicating a reasonable level of compliance with expectations. The greatest variance occurred in land system 25, where 15 quadrats were recorded instead of 8. While these variations may appear large within the context of the survey, the survey itself is such a small fraction of the total survey area, the overall effect is not significant. In fact, given the density of artefact distributions across the landscape, the results indicate that this approach offers an efficient method for rapid assessment of archaeological variability.

## RESULTS

Five hundred and twenty five quadrats were surveyed. Six thousand and thirty seven artefacts were recorded from 214 of the quadrats. The frequency of artefacts in these quadrats varied from 1 to 700, with a mean of 28.2. On the basis of a crude extrapolation from the results of this sur-

TABLE 1. Transect and quadrat data for the study area.

Land System	Unit no.	Area (km <sup>2</sup> )	Expected Distance	Surveyed Distance	Expected Quadrats	Surveyed Quadrats
Area A						
H3/S1	1	4	8.2	8.2	33	33
A6	3	5	1.0	1.0	4	4
R3	4	44	8.6	7.8	34	31
H3/H4	5	62	12.4	12.2	50	49
R3	6	31	6.2	4.7	25	19
W7	7	3	0.6	0.6	2	2
S1	8	10	2.0	2.2	8	9
H3/A3	9	14	2.8	3.0	11	11
H3	10	9	1.8	1.5	7	6
S1	11	2	0.4	0.5	1	2
H3	12	8	1.6	1.8	6	7
R3/H4	13	2	0.4	0.4	2	2
Sub-total		232	46.0	43.9	184	176
Area B						
D8	14	9	1.8	1.8	9	9
S2	15	5	0.9	0.6	5	4
S2	16	2	0.4	0.4	2	2
S2	17	2	0.4	0.4	2	2
S2	18	8	1.7	2.4	9	12
S2	19	4	0.8	0.6	4	3
S2	20	18	3.6	3.0	18	15
M2	21	2	0.4	0.4	2	2
M2	22	1	0.3	0.2	2	1
W6/M2	23	7	1.4	1.0	7	5
S1	24	7	1.3	1.4	7	7
D7	25	8	1.5	3.0	8	15
D7	26	73	14.6	14.0	73	71
H3	27	44	8.6	7.6	43	38
D7/S2	28	157	31.2	31.4	156	157
D7/S2	29	6	1.2	1.2	6	6
Sub-total		353	70.1	69.4	353	349
Total		585	116.1	113.3	537	525

vey, a minimum of approximately 151 million artefacts will be found differentially scattered across the study area, with a mean density of approximately 26,000 artefacts/km<sup>2</sup>.

Of the quadrats with artefacts, three percent (N=14) contained 100 or more. These had a combined total of 4,360 artefacts or 72% of the total

number recorded. Sixty three quadrats (12%) contained between 1-10 artefacts each. The total of artefacts in these quadrats was, however, only 180, or 3% of the total.

The predominant artefact type was the flake, which accounted for 60% (N=3618). Other types with relatively high representation were cores (8.7% or N=528), of which 56% were multiplatform cores; retouched flakes (11% or N=661) and snapped flakes (3.4% or N=206). Formal tool types were poorly represented. Seventeen tulas, two unifacial points, three pirri points, 10 asymmetric backed blades, one edge ground axe, two hammerstones, three grindstones and three (unrelated) mullers were recorded. Artefacts recorded during the reconnaissance survey, but not on this survey were bipolar cores, cylindro-conical stones and ochre nodules. Eight conjoin sets were also recorded, although these were too poorly represented and with too few artefacts to enable technological analysis.

Seventy eight artefacts were made from raw material other than silcrete. Forty nine were from chert, 4 from sandstone, 1 from volcanic material and 24 from unidentified raw materials.

Explanations for patterning in the archaeological record were explored by addressing five working hypotheses. These were based on the concept that the distribution of archaeological material is the result of behaviour and discard, accumulation and postdepositional factors.

*Hypothesis 1.* That the observed distribution of artefacts can be attributed to the recording conditions or postdepositional erosion. These are vegetation cover, the nature of the surface the archaeological material is on, and the type, depth and extent of erosion that the surface is exposed to.

Even though artefacts may be continuously distributed across the landscape, a number of post-

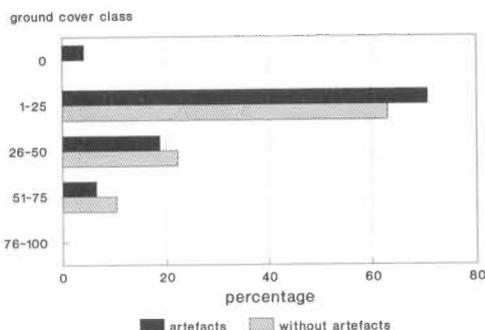


FIG. 5. Quadrat comparison for ground cover class.

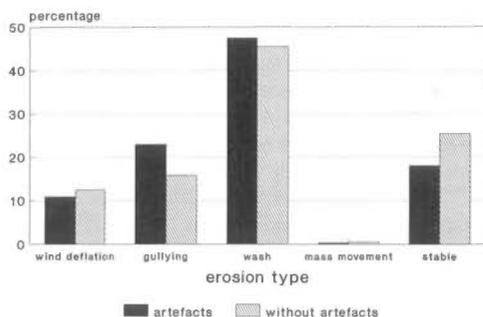


FIG. 6. Quadrat comparison of erosion types.

depositional factors or recording conditions, rather than human behaviour, may significantly influence the patterns observed in the archaeology. These can include differential burial, exposure, mixing or removal of artefacts as the result of the combination of the actions of a number of natural agencies (Kirkby & Kirkby, 1976; Foley, 1981a, 1981c; Butzer, 1982; Schiffer, 1987; Johnson, 1990; Renfrew & Bahn, 1991).

Figure 5 presents a vegetation cover comparison between quadrats with artefacts and quadrats without artefacts. The majority of quadrats had some form of vegetation cover, with the greatest percentage between 1% and 25%. As ground cover increased the frequency of artefacts recorded diminished. However, the representation of quadrats with artefacts and those without artefacts remains approximately constant. This indicates that the diminution in artefact numbers cannot be attributed to increased ground cover restricting observation.

Figure 6 presents a comparison of erosion types. Some form of erosion occurred in 78% of the quadrats. Of the erosion types recorded, wash was the major contributor with 46.3%. Although wash had the highest representation, quadrats with artefacts are represented only marginally (2%) more than quadrats without artefacts. The highest variance (7%) between quadrats with and without artefacts occurs in those with gullying. Quadrats with artefacts in them had almost twice the mean depth of erosion than those without; 18cm to 10cm. In contrast, the mean extent of erosion was similar; 36% to 34%. However, gullies are a potential source of temporary water and the over-representation of artefacts in them may be due as much to this fact as to exposure of artefacts (see below). With such a low overall vari-

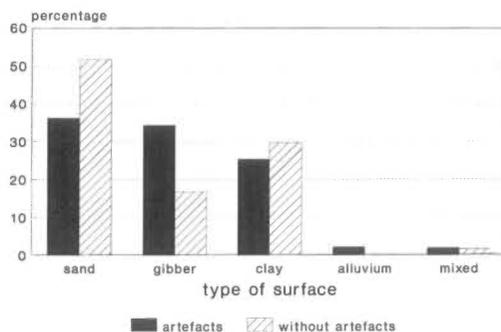


FIG. 7. Quadrat comparison for surface types.

ance between quadrats with and without artefacts, type or extent of erosion can not be regarded as factors that are biasing archaeological distributions. Depth of erosion, however, is a potentially important factor in exposing evidence.

The surface upon which artefacts are deposited may also influence their subsequent recording (Fig. 7). Equally, it may have influenced their initial deposition. Quadrats with artefacts in them are under-represented in both sand and clay surfaces; 36% to 52% in the case of sand and 25% to 30% in the case of clay. They are over-represented in quadrats in gibber; 33% to 17%. Chi square comparisons indicate the sand ( $\chi^2 = 4.32$ , d.f.=1,  $P = 0.03$ ) and gibber ( $\chi^2 = 6.57$ , d.f.=1,  $P = 0.01$ ) differences are significant, but not the clay ( $\chi^2 = 0.63$ , d.f.=1,  $P = 0.43$ ).

The results from both the experimental work and excavation at Youlain Springs indicate that artefacts can easily be incorporated into a sandy surface, significantly effecting their visibility (Robins, 1993; this volume). Even though sandy surfaces may be preferred camping places, vertical displacement in sand could account, in part, for artefact under-representation. The other important factor is that because sand is so common, the presence of artefacts in sand may be correlated to some other factor, such as water. Although it is harder to recognise artefacts on a gibber surface than it is in sand or clay, the fact that gibber is a source of raw material may account for its over representation. Only small numbers of quadrats were in alluvium or mixed surfaces and only small numbers of artefacts were recorded in them. There is insufficient evidence in these cases to postulate any particular explanation to account for the pattern.

If there was a cultural preference for slopes with a particular orientation, or if a natural force such as wind, differentially erodes the land surface, then it could be expected that particular slope orientations may have a greater representation than others. Artefacts were found in each of the nine categories of slope direction (Fig. 8). The categories most frequently recorded and with the greatest numbers of artefacts were north, east, south, west and flat. This may, in part, be due to the character of the landscape, much of which consists of east-west oriented valleys and spurs and a number of north-south and east-west flowing streams. It also may reflect a lack of discrimination on the part of recorders, possibly because determining orientation on an uneven land surface can only be done to a general level. Artefacts were under-represented in the north and flat categories and over-represented in the east and west categories. The south category had equal representation. Because of the potential bias involved in the recording this it will not be explored further.

The angle of slope on all the sampled quadrats varied from 30° to 0°, although 95% of them had slopes of <10°. Only 12 (2%) of quadrats had slope angles >20°, and of these 5 (42%) had artefacts. The mean slope angle of quadrats with artefacts was 6° compared to 5° for those quadrats without artefacts. The slope angle of quadrats was therefore not a determining factor for artefact presence.

Although some recording conditions and types of postdepositional disturbance have an influence on the recorded artefact pattern, that pattern cannot be accounted for solely by one or a combination of these factors.

*Hypothesis 2.* That the nature of, and proximity to, flakeable stone will affect the character of the artefact assemblage.

It can be expected that:

a) The nature of the raw material will influence the pattern of artefact distribution. There will be: 1. a preference for particular types of raw material; and, 2. a preference for a particular size of raw material.

b) Access to raw material will influence the pattern and character of the artefact assemblage. The further away from a stone source: 1. the fewer the stone artefacts; 2. the smaller flakes and cores will become; 3. the greater the ratio of re-touched flakes to non-retouched flakes; 4. the greater the ratio of multi-platform cores to single

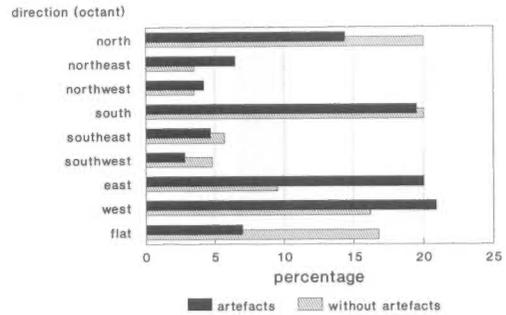


FIG. 8. Quadrat comparison for slope direction.

platform cores; and, 5. the greater the reduction in the percentage of flakes and cores with cortex.

Archaeologists ascribe meanings to stone artefacts using a number of interpretive frameworks including culture, function, demography, ecology, economy, technology and the environment. Within Australian archaeology there has been increased questioning of approaches to stone artefact analysis that has resulted in:

a) A challenge to conventional approaches that attempt to interpret stone artefacts in terms of culture markers or function (e.g. O'Connell, 1977; Hayden, 1979; Hiscock 1983; Bird, 1985).

b) A questioning of the inferences implicit in many archaeological interpretations based on stone artefacts. Davidson's (1988) alternative explanation of Gould's (1980) 'righteous rocks' at Puntatjarpa, and Hiscock's (1981) counter-explanation to Hughes (1980) and Hughes & Lampert's (1982) interpretation of 'site usage intensity', are good examples.

c) Increasing interest in alternative ways of interpreting stone artefacts that include studies on rationing (e.g. Byrne, 1980; Hiscock, 1987), use-wear (e.g. Kamminga, 1982), residues (e.g. Fullagar, 1986), economy (e.g. Bird, 1985) and technology (e.g. Hiscock & Hall, 1988).

These approaches reflect an increasing caution on the part of archaeologists to ascribe meaning to artefacts using traditional methods while at the same time exploring new avenues. While some of them are clearly beyond the scope of this research, they do indicate the variety of ways the archaeological record can be approached. The nature of the archaeological evidence for the study area clearly precludes some explanatory approaches. With little likelihood of faunal or floral data, studies relating to diet and seasonality cannot be profitably pursued with the evidence at

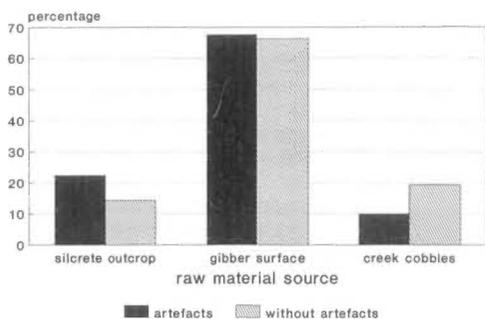


FIG. 9. Quadrat comparison for closest raw material source.

hand. Other aspects of the study area also limit the types of analysis that can be carried out on stone artefacts. The great majority of artefacts are likely to be made from silcrete, but since the source of the silcrete is ubiquitous for large parts of the study and adjoining area, sourcing studies cannot be done.

This hypothesis therefore addresses a basic issue; that of anticipating what might be expected to happen to artefacts in response to decreasing access to raw material the further people travel from raw material sources. It is posited in order to ascertain if there are alternatives to explanations that interpret artefact distribution solely as a response to subsistence (food gathering) strategies. By addressing these hypotheses, the influence of access to raw material can be explored. As O'Connell points out '... both access to and the mechanical characteristics of lithic material need to be considered in defining implement categories and in assessing the significance of variation in the frequency of those categories between assemblages' (O'Connell, 1977: 281).

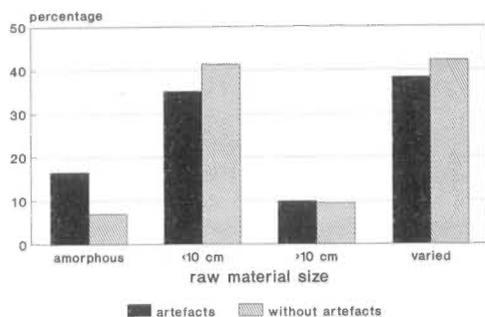


FIG. 10. Quadrat comparison for raw material sizes.

The only stone raw material type found in the study area is silcrete. It can be obtained from three sources; outcrops, gibber surfaces or creek cobbles. Of these, gibber surfaces were the closest raw material source for over 60% of the quadrats (Fig. 9). Quadrats with artefacts in gibber surfaces have the same representation as quadrats without. Quadrats closer to silcrete outcrops and creek cobbles have approximately the same representation, although quadrats with artefacts are over-represented for outcrops and under-represented for creek cobbles. However, chi square comparisons indicate that the under-representation for creek cobbles ( $\chi^2 = 3.18$ , d.f.=1,  $P=0.07$ ) and the over-representation for outcrops ( $\chi^2 = 1.19$ , d.f.=1,  $P=0.27$ ) are not significant.

Of the four classes of raw material size, <10cm and the 'varied' dominate with approximate equal representation. Although artefacts are under-represented in both cases, it is not significant (<10cm  $\chi^2 = 0.76$ , d.f.=1,  $P=0.38$ ; varied  $\chi^2 = 0.56$ , d.f.=1,  $P=0.67$ ). Quadrats where the dominant silcrete source is >10cm are represented in 10% of the sample with equal representation for quadrats with and without artefacts. Although the quadrats with artefacts in the amorphous category are represented by only 13% of cases, the comparison with quadrats without artefacts is near significant ( $\chi^2 = 2.32$ , d.f.=1,  $P=0.13$ ) (Fig. 10). The data indicate that there is no preference for particular types of raw material and only a slight preference for the amorphous (outcrop) size category.

The mean distance to the nearest source of raw material for quadrats with artefacts was 1.3km compared to 2.2km for quadrats without. Irrespective of the source of raw material, the distance for quadrats with artefacts was less than for quadrats without. The frequency of stone arte-

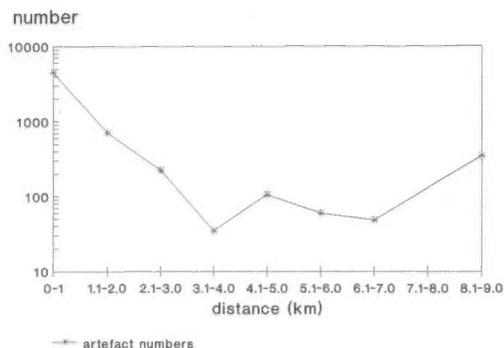


FIG. 11. Artefact frequency with distance from the nearest stone source.

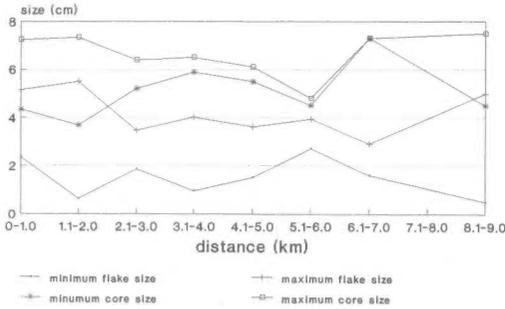


FIG. 12. Flake and core size against distance from the nearest stone source.

facts declines rapidly with increasing distance from a stone source - from 4,472 at the source to 709 within the first 2km (Fig. 11). Frequency further declines to the 3km mark, rises slightly to 105 at the 4.1-5.0km mark and declines to 0 at the 7.1-8.0km mark. At the 8.1-9.0 mark there is an increase to 350. This observation supports the hypothesis that the further away from a stone source the lower the frequency of artefacts, although the pattern is more complex than one of straight line decay.

Figure 12 plots the mean minimum and maximum flake and core size against distance from a stone source. Mean minimum and maximum core sizes at the source are 4.3cm and 7.2cm respectively. As the distance from the source increases the mean maximum size decreases while the mean minimum size increases, presenting a constricting envelope of values to the 6.1-7.0km mark. Values are absent between 7.0 and 8.1km,

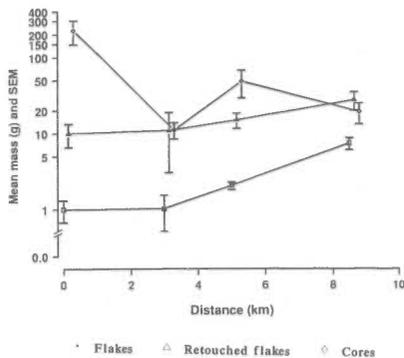


FIG. 13. Mean and standard error of the mean for mass of artefacts with increasing distance from the nearest stone source.

but at the 8.1-9.0km mark, sizes return to approximate the source values. A similar pattern is found for flakes. The maximum flake size overlaps that of the minimum core size, but within 3km the sizes separate to form a distinct envelope. The mean maximum diminishes slightly to the 6.1-7.0km mark, while the mean minimum increases slightly. As with the cores, there are no values between 7.0 and 8.1km. Between 8.1 and 9.0km the minimum and maximum sizes approximate source values and the maximum overlaps with the minimum core size. Flake and core sizes do diminish with distance from the nearest stone source up to about 8km, when they increase to approximate dimensions at the source.

Further confirmation of this pattern was obtained from artefact collections undertaken at Youlain Springs, Bokeen Bore, Riley Springs and L. Numulla 3 & 4 as part of a more detailed study of selected sites undertaken to complement the nonsite survey (Robins, 1993). These sites lie 0, 3, 5 and 8km respectively from the nearest source of flakeable stone. Figure 13 compares the mean mass and the standard error of the mass for flakes, retouched flakes and cores. Uniformity in raw material type, size range and geometry of the artefacts produced from this material, makes mass a suitable measure of comparison. Mass is also likely to be an important factor in the selection of raw material to transport. The chart indicated that there is sudden decline in the mass of cores away from a raw material source. At 5km, there is a slight rise, then it falls at 8km. Retouched flakes, on the other hand, increase in mass away from the source. Significantly, at 8km both cores and retouched flakes have a similar

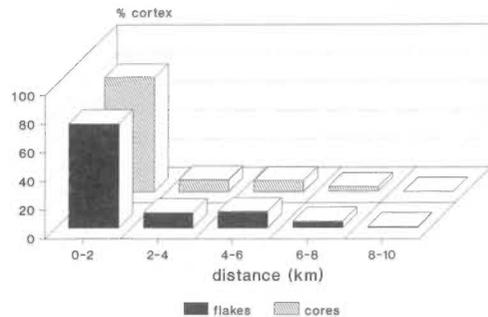


FIG. 14. Cortex reduction with distance from the nearest stone source.

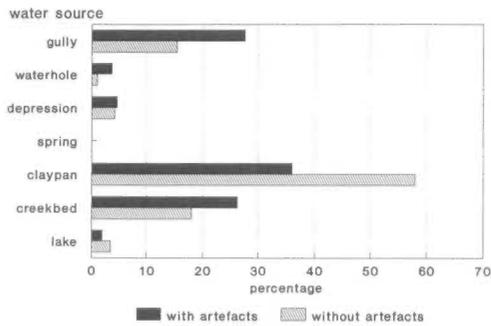


FIG. 15. Quadrat comparison for the nearest source of temporary water.

mass. The mass of flakes also rises with distance from a stone source.

The ratio of flakes to retouched flakes remains constant at 5:1 up to 8km from the nearest stone source and then decreases to 12:1. The prediction that the ratio between flakes and retouched flakes will increase with distance from a stone source is not supported. The ratio of multi-platform cores to single platform cores is about 1:1.6 up to 2km from a stone source and increases to 1:1 up to 6km from a stone source. The numbers are too small to demonstrate relationships for greater distances. There is some support for the prediction that the ratio of multi-platform cores to cores increases with distance from the nearest stone source.

There is a clear decline in the percentage of flakes and cores with cortex with distance from a stone source (Fig. 14). There is a rapid decline within the first 2km, a levelling out between 2km and 6km at around 10%, followed by a further decline in values. Cores with cortex were not found 8-10km from a stone source. The prediction that there will be a reduction in the percentage of flakes and cores with increasing distance from a stone source was supported.

An explanation for the observed pattern of artefact distribution is as follows. The predominant form of silcrete is creek cobble or gibber. In most of the areas where it occurs, it presents as rounded stone of varying size with a weathered, patinated, and oxidised surface. If the raw material is to be transported considerable distances, good quality stone needs to be identified. The only way to ensure its quality is to flake it. Sufficient flaking therefore has to be done at the source to confirm the quality of the stone and to reduce the amount of unwanted material, including cortex. Sources

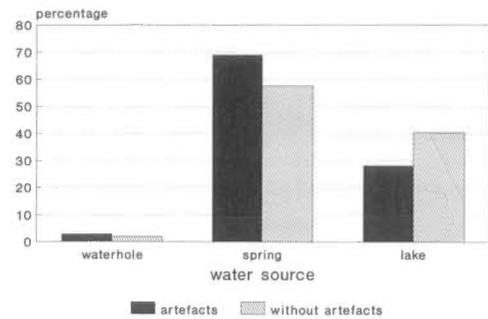


FIG. 16. Quadrat comparison for the nearest source of permanent water.

of stone will therefore have a high percentage of large cores, and a high percentage of small flakes as a result of the initial attempts to reduce the cores. Large cores, retouched flakes and flakes are then carried relatively long distances to areas where there are no stone sources. Because much of the reduction is done at the source, less reduction and manipulation of the core is required away from the source and there are relatively fewer small flakes. This pattern also suggests that places in the environment that are a considerable distance from stone sources, will serve as redistribution points, and that these redistribution points are embedded in the landscape at regular intervals.

*Hypothesis 3.* That the distribution of artefacts will reflect access to potable water sources, particularly permanent water. This will be indicated by:

- A strong correlation between water sources and artefact discard.
- The closer the permanent water source the greater the artefact numbers and artefact diversity.

As the study area is located in a landscape which is characterised by evaporation exceeding precipitation and a highly irregular rainfall, access to reliable water sources could be expected to be paramount for any human population. This hypothesis explores that relationship. It is based on the assumption that numbers and diversity of artefact types are related to frequency of occupation. The greater the frequency of occupation, the greater the number of artefacts and the greater the artefact diversity. Diversity is measured using the artefact classes identified during the survey. The more types the greater the diversity. The discus-

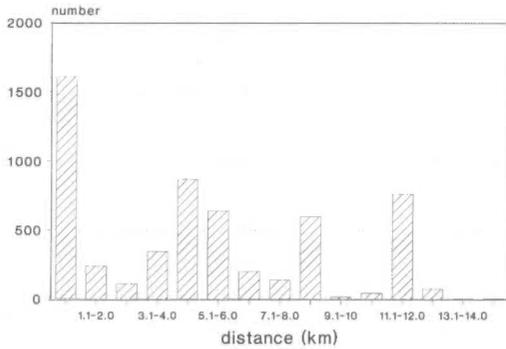


FIG. 17. Artefact frequencies from the nearest source of permanent water.

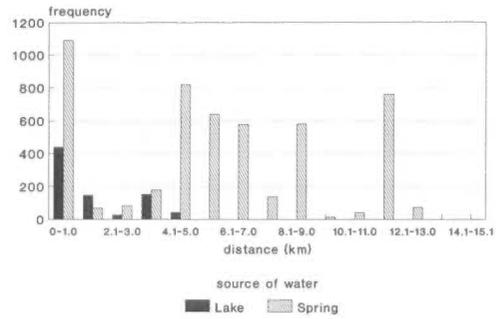


FIG. 18. Artefact frequencies with distance from lakes and springs compared.

sion accompanying Hypothesis 5 elaborates on the concept of diversity.

The mean distance to a temporary water source for quadrats with artefacts was 200m compared with 300m for quadrats without. The dominant temporary water sources were claypans (49%), gullies (20%) and creekbeds (21%). Of these, quadrats with artefacts were over-represented where gullies and creekbeds were the closest source of water. This over-representation was, however, only near significant (gully  $X^2=3.53$ , d.f.=1,  $P=0.06$ ; creekbed  $X^2=1.84$ , d.f.=1,  $P=0.18$ ). Where claypans were the closest source of water, quadrats with artefacts were under-represented. This under-representation was significant ( $X^2=1.84$ , d.f.=1,  $P=0.002$ ). As claypans are such a common feature, this result possibly indicates preference for particular claypans with particular characteristics. The characteristics of claypans were not investigated for this study. Waterholes, lakes and depressions had only a minor representation (5%). Springs were not represented at all (Fig. 15).

When distance to permanent water sources is considered, the role of springs is reversed. Figure 16 illustrates the distribution of quadrats with respect to the nearest source of permanent water sources. For the purposes of this study, L. Numulla was considered a permanent water source. Sixty two percent of quadrats are closer to a spring than any other source of permanent water. Lakes are the closest source of permanent water for 36% of quadrats and waterholes for 2%. Quadrats with artefacts are over-represented for springs, and under-represented for lakes. However, the artefact over-representation for springs is only near significant ( $X^2=2.89$ , d.f.=1,

$P=0.09$ ), as is the under-representation for lakes ( $X^2=3.21$ , d.f.=1,  $P=0.07$ ).

Figure 17 presents a graph of artefact numbers against increasing distance from a water source. High artefact frequencies ( $N=1,608$ ) were recorded close to permanent water sources. Numbers rapidly diminish away from the permanent water source to the 4km mark ( $N=110$ ), rise again between 4.1 and 5.0km ( $N=867$ ) and fall between 7.1 and 8.0km ( $N=139$ ). This pattern is repeated twice more to the limit at 15.1km. The distance between peak occurrences are roughly similar and occur at 3.5km, 4.5km and 3km respectively.

In figure 18, this relationship is further examined by presenting artefact numbers against distance from the two major sources of permanent water; lakes and springs. Two points can be made. Artefacts can be no further than 5km from a lake before they become close to another source of water, whereas artefacts can be up to 15km from a spring and not be close to another permanent water source. The second point is that artefact numbers close to the lake ( $N=440$ ) are considerably less than those close to springs ( $N=1,090$ ). However, the pattern observed above still prevails. That is, artefact numbers decline rapidly away from the lake, rise slightly at the 3km-4km mark and fall again. A similar pattern occurs with the spring data although greater numbers of artefacts are involved. The major difference in the pattern occurs at the 4.1-5.0km mark where the lake numbers drop while the spring numbers rise. The spring pattern duplicates the results obtained for the total assemblage.

The Spearman rank correlation coefficient for the number of categories and number of artefacts comparison (a measure of diversity) is 0.937

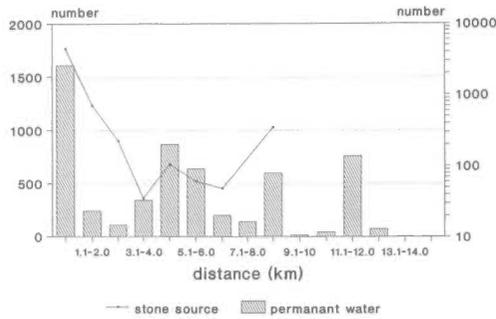


FIG. 19. Artefact frequencies from permanent water sources compared with the distance from nearest stone source.

( $P < 0.001$ ) indicating a highly positive association between increasing numbers of artefacts and increasing numbers of types. Because there are high artefact numbers and types (diversity) near springs, this part of the hypothesis is proven. However, although artefact numbers diminish with distance away from springs, there is considerable fluctuation in numbers, and there are points on the landscape at some distance from springs that have relatively high artefact numbers and diversity. The spacing of these points is similar to that reflected in the distance from stone sources (Fig. 19). This pattern indicates that numbers of artefacts are strongly associated with permanent water sources, but that the overall pattern of artefact distribution reflects an embedded resource distribution strategy designed to maximise access to raw materials from all points in the landscape.

*Hypothesis 4.* That unique artefact assemblages reflect the exploitation of particular environments.

This hypothesis is based on the assumption that particular environments will have embedded in them particular resources, the exploitation of which will be reflected in the archaeological record. It is not uncommon for archaeologists to use environments as the basis for their archaeological work, and in turn explain patterns in the archaeology by referring to those environments. In doing so, a connection between environment and behaviour may be implied, that is, a specific set of environmental characteristics (e.g. land system, vegetation type) is identified as the 'cause' of archaeological variability.

This approach faces a number of theoretical and practical problems. The first lies in identifying alterations to the surrounding environment during the period of the formation of the archaeological record. Over long periods of time, particularly where there has been evidence of significant climatic change, environmental change is an important variable that needs to be accounted for.

The second problem lies with characterisation of the environment itself. Land systems, for example, do not define 'the environment'. They are a means of interpreting the systematic relationship of specific environmental characteristics within a given area. The term 'land system' was defined by Christian & Stewart (1953: 21) as 'an area, or groups of areas, throughout which there is a recurring pattern of topography, soils, and vegetation'. As some authors (Story et al., 1976; Pickard & Boyland, 1981) point out, land system identification can be problematical. Different land system studies of adjoining regions can produce different results if different methods or criteria have been used (Pickard & Boyland, 1981). The particular emphasis used in defining environments will have implications for archaeological interpretation. It has been demonstrated, for example, that the interpretation of site patterning and site/environment relationships on Moreton Island will differ according to whether a vegetation or land system approach is adopted (Robins, 1983: 140). However, for the purpose of this research the land systems will be taken to represent the 'environment'.

An added difficulty for environmental interpretation is one of identifying boundaries. Boundary lines on maps are a convention that can obscure reality. While natural features; soils, geological formations and vegetation types, may at times be differentiated by a sharp boundary, in many other cases the boundary is a broad and diffuse zone of mixing. In these circumstances it is always possible in the field context, to assume to be in one zone and in fact be in another.

The fourth problem with this approach is the difficulty in allying particular resources with the artefactual record. Without undertaking detailed analyses of both environmental resources and artefacts, it is not possible with any degree of certainty to identify what artefacts were used to exploit particular resources. Because of its complexity such an approach is not an appropriate one for an exploratory survey. It can be attempted at a more general level by assuming that particular artefact types are associated with the exploita-

TABLE 2. Artefact frequencies by land system.

Land system	Land SystemNo.	Quadrats Sampled	Quadrats with Artefacts	Total No. of Artefacts	Max. No. of Artefacts	Min. No. of Artefacts	Mean No. of Artefacts
H3	1	33	12	45	12	1	3.8
A6	3	4	4	834	487	52	208.5
R3	4	31	16	592	234	1	37.0
H3/H4	5	49	33	1061	618	1	32.2
R3	6	19	14	593	540	1	42.4
W7	7	2	1	70	70	70	70.0
S1	8	9	6	27	9	91	4.5
H3/A3	9	12	1	1	1	1	1.0
H3	10	6	5	289	270	2	57.0
S1	11	2	0	0	0	0	0
H3	12	7	7	935	700	2	133.6
H4/R3	13	2	1	13	13	13	13.0
D8	14	9	1	1	1	1	1.0
S2	15	4	0	0	0	0	0
S2	16	2	0	0	0	0	0
S2	17	2	1	22	22	22	22.0
S2	18	12	3	7	4	1	2.3
S2	19	3	0	0	0	0	0
S2	20	15	2	7	6	1	3.5
M2	21	2	0	0	0	0	0
S2	22	1	0	0	0	0	0
W6/M1	23	5	5	9	2	1	1.8
S2	24	7	0	0	0	0	0
D7	25	15	4	22	14	2	5.5
D7	26	71	17	625	346	1	36.8
H3	27	38	22	88	10	1	4.0
D7/S2	28	157	57	538	109	1	9.4
D7/S2	29	6	2	221	191	30	110.5

tion of particular resources. The number of artefacts this can be applied to, however, is limited and does not cater for the majority, including cores and flakes. An alternative approach is to examine the relationship between the general distribution of artefacts and particular environments (as characterised by land systems) or particular aspects of the environment.

Because of these problems, this research does not adopt a perspective that postulates a particular relationship between people and environment that will be reflected in the archaeology in a particular, defined way. Rather, it is assumed that *if* there is a relationship between environments and

artefact distributions it will be reflected in: a) unique artefact assemblages for each type of environment; and, b) similar environments being used in similar ways.

There are two elements to proving this hypothesis. The first is to identify characteristics in the artefact assemblages for each land system or land system type. The second is to determine if those characteristics are functionally meaningful and reflect cause and effect.

Table 2 presents a summary of the numbers of artefacts recorded for each land system represented in the survey. There is an uneven artefact distribution across the surface of the study area. In some land systems (for example 11, 15 and 16), no artefacts were found while in other cases (for example 12 and 23), artefacts were found in every quadrat surveyed. Within particular land system types, some quadrats

have artefacts and others do not. For example, three of the S2 land systems had no artefacts, and three did. Where artefacts are represented within a land system type, their densities can be highly variable. For example, the mean number of artefacts recorded in quadrats in the D7 land system varies from 5.5-36.8. There is, furthermore, little correlation between the number of quadrats sampled within a land system and the number of artefacts recorded. In land system 28 (D7/S2), 57 quadrats of the 157 sampled yielded artefacts with a mean of 9.4. Land system 29 (D7/S2) on the other hand, had, from a sample of six quad-

TABLE 3. Logistic regression by land system types using dichotomous (v.1.) artefact values and counts (v.2).

Variables	Land System				
	R3	H3	D7	S2	D7/S2
v.1					
22		0.0001			
37					0.0001
44	0.020				
48			0.005		
80			0.02		
87			0.003		
97			0.012		
v.2	R3	H3	D7	S2	D7/S2
22		0.0001			
25					0.001
26	0.0002				
45					0.047
48			0.018		
80			0.039		
87			0.005		

rats, two quadrats with artefacts with a mean of 110.5.

Logistic regression was used to identify artefact assemblage features predictive of land systems. Regression analysis is used as a means of modelling an outcome (dependent variable) as a linear combination of some explanatory variables of interest (independent variables). Another way of expressing this concept is determining which variables for which data have been collected, best predict another variable of interest. The emphasis in regression analysis is on prediction of the value of one variable given the values of other variables, as opposed to correlation analysis which quantifies only the strength of association between two variables. The specific type of regression analysis used is dependent on the form of the distribution of the outcome variable of interest, e.g. normal, binomial or Poisson, however the basic relationship between outcome and explanatory variables remains the same (Kelsey et al., 1986).

The most familiar form of regression analysis is linear regression analysis in which the outcome or dependent variable is continuously distributed (normal distribution) such as height and might be explained by other variables such as weight or age. The regression model fitted in this case takes the form:

$$\text{dependent variable} = \eta + E$$

where E is an error variable taken to be normally distributed and  $\eta$  is a linear combination of regression or explanatory variables.

When the outcome variable takes only two values it is said to be dichotomous and has a binomial distribution. In this instance another form of regression analysis, logistic regression analysis, is the appropriate technique.

The regression model fitted in this case has the form:

$$\text{dependent variable} = (\exp \eta) / (1 + \exp \eta)$$

where again  $\eta$  is a linear combination of the regression or explanatory variables (Hosmer & Lemeshow, 1989; Schlesselman, 1982).

Coefficients are derived for each of the explanatory variables with a positive coefficient indicating a positive or direct relationship, i.e. the dependent variable will be larger when the value of the regression variable is larger, and a negative coefficient indicating a negative or indirect relationship. The interpretation of the coefficients of the explanatory variables that result is the same regardless of which form of regression analysis is used.

Multiple linear regression has a fairly lengthy history of application in science. However, logistic regression analysis is a more recent analytical tool. The regression equation in logistic regression is solved iteratively and only recent developments in computer technology in the past decade have made its application feasible. Logistic regression is an appropriate analytical technique when the outcome variable is dichotomous or binomial, regardless of what the origin of such data might be. In the present study, logistic regression provides an efficient technique for evaluating variables which define given sample quadrat types. The outcome of interest is defined as membership in a given type of quadrat versus non-membership of that type of quadrat, and each type of quadrat is examined separately in this manner. This type of analysis allows identification of the variables specifically predictive of being a given type of quadrat versus not being that type of quadrat, and handles the different types of variables that need to be considered in an archaeological setting (C. Swanson, pers. comm.).

The land systems selected for analysis were those that were represented by at least two examples for comparison. To ensure a reasonable sample size, each land system represented had to have at least ten quadrats with artefacts in them. Five land systems met these criteria; R3, H3, D7,

TABLE 4. Logistic regression by land systems using independent dichotomous values (bracketed variables are near significant).

Variables	Land System				
	4 (R3)	6 (R3)	10 (H3)	12 (H3)	27 (H3)
2				0.007	
9	0.033				
10	0.038				
11	0.012				
13				(0.127)	
22					0.0001
34				(0.095)	
44		0.020			
60			0.014		
	25 (D7)	26 (D7)	28 (D7/S2)	29 (D7/S2)	
3		0.029			
37				0.0001	
44			0.004		
48		0.005			
80		0.024			
87		0.003	0.001		
97		0.012			

S2, and D7/S2. In each case the P values were based on the maximum likelihood estimates. Four regressions were run. The first regression used dichotomous (presence/absence) values for the variables (artefacts), but combined identical land system types.

This resulted in the characterisation of each land system type. The predictor variables for the land systems types were: R3 (1-5cm silcrete flakes); H3 (>10cm silcrete flakes); D7 (<1-5cm silcrete flakes, 1-5cm chert retouched flakes, sandstone muller, silcrete manuport); S2 (no predictor variables), and; D7/S2 (<1cm silcrete snapped flakes) (Table 3). The second regression used actual artefact counts. The predictor variables for the land system types were: R3 (chert flakes >10cm); H3 (silcrete flakes >10cm); D7 (silcrete retouched flakes <1cm, chert retouched flakes 1-5cm, and sandstone muller); S2 (no variables), and; D7/S2 (silcrete flakes <1cm, silcrete retouched flakes <1cm) (Table 3). In only one case, that of H3, was the predictor variable the same, although D7 shared two predictor variables out of a possible five. Each land system type has a unique predictor pattern. This pattern varies de-

pending on how the predictors are defined (actual counts or presence/absence). The third regression (Table 4) treated each land system independently, using dichotomous (presence/absence) values for the variables (artefacts). From this table it can be seen that each land system has different predictor variables. The same applies for the logistic regression based on actual counts (Table 5).

For the purpose of this discussion, the relevant issue is that similar land systems do not have similar predictor variables and that the intra-land system variation is as great as the inter-land system variation. The hypothesis that unique assemblages reflect the exploitation of particular environments was not supported. The fact that some land systems can be characterised by unique assemblage traits may not contribute a great deal to an understanding of the behaviour associated with the exploitation of that environment. It is difficult to interpret for example, what is behaviourally significant about the relationship between land system 12 (H3) and silcrete retouched flakes <1cm, or land system D7/S2 and silcrete flakes <1cm.

On the other hand, the presence of a particular attribute may be explicable on grounds other than those of that particular environment, that is, they may relate more to features within land systems, such as the proximity to a particular stone source or water source. The fact that retouched chert flakes were selected as a predictor for D7 land systems may have little bearing on its 'D7-ness', and more on access to raw materials. It may also be that the survey sample is too small to characterise differences at this level or that a different approach, perhaps a site oriented one, is more appropriate to characterise exploitation of different environments.

*Hypothesis 5.* That the use of an area can be characterised grossly by the relationship between assemblage diversity and assemblage size. Frequently used areas will be characterised by large numbers of artefacts and high assemblage diversity. Areas infrequently used will be characterised by low numbers of artefacts with a low assemblage diversity.

One of the central aims of hunter-gatherer archaeology has been to attempt to reconstruct the use of sites or landscapes on the basis of the discard left behind. A common approach to this problem has been to draw on ethnography or ecology to elicit general rules or to obtain direct analogues which are then used as predictive mod-

TABLE 5. Logistic regression by land systems using artefact counts.

Variables	Land System				
	4 (R3)	6 (R3)	10 (H3)	12 (H3)	27 (H3)
11	0.007				
22					0.001
26		0.020			
43				0.003	
90			0.009		
	25 (D7)	26 (D7)	28 (D7/S2)	29 (D7/S2)	18 (S2)
25				0.001	
45				0.047	
48		0.018			
80		0.039			
83			0.019		
87		0.005			
88					0.0001

els. This results in radial models of diminishing activity; the base camp is the focus, with a series of specialised activities, often seasonally related, carried out with diminishing frequency as distance from the base camp increases (e.g. Thomas, 1973; Foley, 1981a, 1981b; Butzer, 1982; Binford, 1983). Habitation sites will have a greater variety of tasks carried out at them and hence a greater diversity of artefact types and raw materials (Gould, 1977: 168). The greater the habitation the greater the number and variety of artefacts. The size of the habitation area can also increase with the frequency of use (Camilli, 1989: 21). Use of the surrounding area varies according to the time spent there and the specific tasks carried out. This form of interpretation gives rise to a variety of site types with their diagnostic tool or artefact assemblage. They can include, for example, animal butchering and plant processing, hunting, fishing, quarrying, and ceremonial sites and rest, dinnertime and short-term camps. (Thomas, 1973; Foley, 1981a; Butzer, 1982; Binford, 1983; Cane, 1984; Jones et al., 1989).

These interpretations raise several problems. The first is whether analogues should be used in this manner; that is, whether the aim of archaeology is to recreate an ethnographic perspective (Robins & Trigger, 1990). The second is whether these models are based on adequate data and whether they really typify hunter-gatherer use of

the landscape (Shott, 1992). While some ethnographic accounts support the notion of discrete sites associated with discrete assemblages scattered across the landscape according to the functions carried out at them (eg. Cane, 1984), other ethnographic data (eg. Anderson & Robins, 1988) suggest that land use can be more complex. This latter study indicates that while some areas are frequented more than others for specific activities, it is not necessarily done to rigidly prescribed formulas. It is thus possible for the same locality to be used for five or six different classes of activity including a base camp, within a short space of time. Thomas, for example, states: 'The degree of observable assemblage diversity is also significantly blurred in the translation from behavioural to archaeological contexts. Hunter-gatherer cultural geography tends to be redundant: abandoned base camps are reoccupied as temporary field camps; functionally diverse field camps are re-established at the same camp; diurnal exploitative areas overlap spatially as seasonal resources ripen. Given sufficient time, residential assemblages commonly become physically commingled with various logistic assemblages. Discrete logistic assemblages accumulate in certain favourable loci; one behavioural accumulation inextricably mixing with another. Rarely is a given location utilised in only one way, and the palimpsest accumulation is an archaeological fact of life' (Thomas, 1989: 87).

The second problem lies in the functional nature of the interpretation. In the Australian context particularly, artefacts form may not equate with function (Hayden, 1977). To support arguments that relate to use (which diversity is presumably measuring) demonstration of function is required. Without carrying out use-wear analysis or residue studies, which were beyond the scope of this study, it may not be possible to identify the functions that were carried out at that location on the basis of the form of the artefacts. Even if such a study could be carried out, it would probably only inform about the last use of the tool, and not its history.

For the purposes of this study three basic assumptions are made.

- 1) That discard will be equated with use.
- 2) That the range of artefact types can be regarded as a crude measure of the variety of tasks carried out. There is sufficient evidence in the literature to substantiate the inference that different artefact types were used to perform different functions. Tulas were used for adzing (Roth,

1904; Horne & Aiston, 1924), unifacial points (including pirri points) for spear points (Kamminga, 1982), grindstones (including mortar and pestles) for processing grass and tree seeds (Smith, 1985, 1988), hammerstones for flaking, axes for wood cutting (Roth, 1904), cylindroconical stones probably for ceremonial functions (Black, 1942) and ochre nodules as a paint source for decoration (Roth, 1904). Although the function of backed blades is unknown, they were probably used as spear barbs for composite spears (Kamminga, 1982). Flakes, retouched flakes and cores will be regarded as an indirect measure of function (flaking). For this study it is assumed that there is sufficient correlation between artefact types and functions undertaken. The greater the variety of types, the more functions carried out.

3) That the number of artefacts will be equated with amount of activity. The greater the number of artefacts, the greater use the area has.

The third problem lies in measuring diversity itself. The concept of diversity has a long, but intuitive history of use in archaeology (Dunnell, 1989; Jones & Leonard, 1989). Recently, archaeologists, borrowing largely from biology and ecology, have attempted to apply more sophisticated measures of diversity to the archaeological record. This issue is, however, a complex one, and a variety of concepts and statistical techniques can be used to measure it. Diversity generally encompasses three concepts: richness, which describes the number of categories used; evenness, which describes the similarity in abundance; and heterogeneity, which assesses the variability in the number of classes and the abundance of individual classes (Bobrowsky & Ball, 1989; Jones & Leonard, 1989). If such concepts can be applied to the data generated by the non-site survey, they may provide sound measures of diversity. However, the application of diversity measures to archaeological data are still in their infancy. Even if successfully applied, their explanatory power is constrained by the type definitions used. Unless the categories (artefact types) that are chosen accurately reflect human behaviour, measures of diversity may relate only to the classification system, and may contribute little to an understanding of human behaviour.

Perhaps the biggest problem with using the concept of diversity is the expectation that '... the diversity of a sample is a direct linear function of the size of the sample' (Thomas, 1989: 86). To overcome this problem Thomas (1989) suggests that within a given system, a relative measure of

assemblage diversity versus assemblage size can be employed to crudely characterise archaeological variability. Base camps will have a profile that has a high assemblage diversity to assemblage size ratio. Field (short term) camps will have an intermediate profile. Diurnal use areas (locations) relate to resources extraction and have the lowest diversity to assemblage size relationship. The archaeological record should be regarded as a continuum ranging from low diversity to high diversity.

This type of analysis only goes part of the way to solving the problem of characterising assemblages as it is still tethered to ethnographic concepts. More importantly, it is an approach more suited to site survey and the identification of the site use. For the purposes of an exploratory survey, a broader characterisation of the diversity of the archaeological record is required. Ebert (1992: 148) points out that while in a purely statistical sense diversity is positively correlated with sample size, there is no reason to expect this relationship in all archaeological situations. Ebert (1992: 148) describes three models of assemblage diversity compared with sample size. The first is the commonly expected 'growth in size : growth in diversity'. The second is a 'linear growth' or 'constant relationship' model where there is a threshold beyond which diversity does not increase with sample size. This relationship might be expected where different activities relating to a small number of subsistence strategies are carried out. The third is a 'growth in size : decrease in diversity' model. This relationship would be expected in areas where the processing of single or small numbers of artefact types in a redundant way, are carried out. Quarries, workshops and knapping floors will produce an archaeological signature that conforms to this model.

Of the three, the first is most likely to conform to expectation. This is the pattern commonly, but not invariably found in other archaeological contexts (eg. Bobrowsky & Ball, 1989; Jones et al., 1989; Thomas, 1989). However, given the large number of flakes, retouched flakes and cores in the sample indicating a relatively high level of knapping in the study area, the 'growth in size: decrease in diversity' model was also a strong candidate.

Both the Shannon-Weiner and Brillouin indices versus number of artefacts and number of types of artefacts were calculated and both indicated a high degree of correlation (in both cases  $P < 0.001$ ). However, in this case the most effi-

cient indicator of diversity (numbers of artefacts versus number of types) was provided by the Spearman rank correlation coefficient. This gave a value of 0.937 ( $P < 0.001$ ) indicating a high correlation between numbers of artefacts and numbers of artefact types. The hypothesis holds; that is, that there is a high correlation between artefact numbers and numbers of artefact types. If the inferences about use, discard and artefact numbers are accepted, then it is possible to identify frequency of use across the landscape.

## DISCUSSION

This research explored the surface archaeological evidence in the vicinity of the Currawinya Lakes, southwest Queensland using a nonsite approach. As systematic sampling is rarely used in Australian archaeology (Attenbrow, 1987), and no published nonsite surveys have been conducted to date in the arid zone, an additional aspect of this survey was to assess the viability of a nonsite approach.

Five working hypotheses were formulated to explore aspects of the archaeological evidence. A stratified systematic transect sample based on land systems was implemented and 525 20m x 20m quadrats were sampled. Two hundred and fourteen quadrats contained a total of 6,037 artefacts. Through the testing of these hypotheses, aspects of Aboriginal behaviour that operate at a scale different to that generally observed when sites are used as the basis survey, were detected. These include a high correlation between stone sources and permanent water sources (particularly springs) and artefact discard. Although numbers of artefacts drop off with distance from stone/water sources, small increases of artefacts at regular distances from these sources were noted. In addition, after an initial drop off, the size of flakes and cores increased with distance from the nearest stone source. These patterns were interpreted as a regional stone rationing response to the biased distribution of stone and permanent water sources.

Nonsite archaeology is a useful approach that provides evidence that other surveys do not. It does this through the collection of negative evidence to provide the control necessary to demonstrate an effect and evidence at a regional scale as opposed to a site scale.

Time taken to implement the survey compared with the number of survey quadrats examined, detail in which they were examined, and number of artefacts recorded suggest that this method was

as efficient as other survey methods (reconnaissance survey and site specific survey) used for this research.

The method proved effective in identifying general patterns of artefact distribution. However, the small sample size, combined with the use of small quadrats, has resulted in an underestimation of artefact numbers at a regional scale. On the basis of a crude extrapolation from the results of the survey, approximately 151 million artefacts will be differentially scattered across the land surface. However, the reconnaissance survey indicated the presence of concentrations of artefacts at specific locations. At one of these sites, Bokeen Bore, there were an estimated 60 million artefacts (Appendix 2). An accurate estimate for artefact numbers is therefore likely to be higher than that provided by the nonsite survey.

These results highlight the limitations of single stage surveys, particularly and perhaps paradoxically, in contexts where limited resources allow for an examination of the landscape at a superficial level. A combination of methods, implemented as stages, and each designed to address issues appropriate to the method used, is a more effective approach for broad regional surveys.

The results also have implications for Foley's model of home-range related behaviour and its testing in the field. It is clear that Foley sees his model as more than a general statement about the formation of the archaeological record. His ecological model is similar to ethnographic models commonly used in Australian archaeology. It is a model that not only predicts particular types of behaviour but also the manifestations of that behaviour in the archaeological record. In this way, it also suffers the limitations of many ethnographically derived models because the behavioural correlates are not unambiguously expressed in the archaeology, or unstated or untestable assumptions are made to link models with the evidence. Artefact function cannot always be readily identified; discard may not reflect use; frequency of use of an area is difficult to characterise on the basis of artefact numbers; and redundancy makes identification of specific areas with particular behaviours difficult to identify. The 'modelling' approach assumes correlations, when, in fact, the initial purpose of the survey should be to establish if such correlates can be identified and applied. The fundamental issue for exploratory survey is to determine the types of questions the evidence can address (within the constraints of the survey) rather than assume the evidence can be used to

address particular models. Once the nature of the archaeological record has been established, models can then be generated from the results of the survey for further testing.

Another reason that the modelling approach may not be applicable to nonsite archaeology has to do with appropriateness of scale. An essential aspect of nonsite archaeology is that it is undertaken using some form of random sampling strategy. The size of the sample unit will have a critical effect on the explanatory perspective adopted. If small sample units are chosen it is unlikely, particularly if the sample fraction is small, that behaviour at the scale required by Foley's model will be detected. That is to say, a 20m<sup>2</sup> quadrat is inappropriate to detect home base behaviour that may take place over hundreds of square metres. This is not a necessary argument for discarding large sample units. Sampling is a flexible tool and there are circumstances when large units are justified and appropriate (eg. Robins, 1983). The size of the sample unit, however, needs to be appropriate to the scale of behaviour being sought. Foley fails to demonstrate that a site based approach, coupled with an appropriate off-site survey strategy would not be a more appropriate way to identify the type of behaviour this model is designed to test.

The concept of 'continuity' of the archaeological record also requires clarification as it is fundamental to Foley's argument for a regional approach. Foley argues (1981b: 3) that 'If activity is spatially continuous and home-range-specific then through the process of discard the material manifestations of that activity should also be continuously distributed'. This concept of 'continuous' runs into the same problem that site definitions do. For example, when does continuous become discontinuous? Is it dependant on numbers of artefacts, density of artefacts, or distance between artefacts? Will the arbitrary selection of criteria result in the creation of spurious archaeological entities. However, Foley (1981a: 13) also suggests that it is 'the regional archaeological structure' that is spatially continuous. This second concept is a more useful one, since the absence of artefacts in particular areas may still be a reflection of the pattern of use for the region. The absence of artefacts in particular areas, therefore, is part of the pattern of regional use, and may only be understood with reference to the presence of artefacts in others, as was the case in this study.

The strength of nonsite archaeology is as a tool that addresses the issue of identifying many ques-

tions the archaeology can address, rather than assuming that it can address the archaeology in only one way. It is thus an excellent tool for exploratory survey. The use of nonsite archaeology is not an argument for the abandonment of the site concept, although this has been proposed (e.g. Dunneil, 1992; Ebert, 1992). In this research, both the site and nonsite concept were used to explain the archaeology. There is no necessary contradiction in this approach. Both methods are simply tools that archaeologists use to attempt to describe, explain and interpret data.

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## APPENDIX I

LAND SYSTEMS. Dawson (1974) has identified 20 different land systems within the study area (Fig. 2). The land systems were compiled by identifying a number of land units on the basis of landform, geology, soils, vegetation, and land utilisation factors. Identification of the land units was obtained through aerial photograph interpretation followed up by ground studies to confirm the land system classification. These included detailed soil and vegetation sampling.

Land systems are made up of one or more land units. The classification is '... based on the recurrence of similar sites or site sequences forming land patterns or sequences' (Dawson 1974:74). For the archaeological questions at hand, environmental description to the level of the land system is sufficient. These land systems precisely depict the character of the environment and a summary, based on Dawson (1974) is given below. Where a land system may contain small but significant inclusions of other land systems that are difficult to map their occurrence is registered by a /.

The Grey (R3) dissected residual land system is found on the western side of L. Wyara. It comprises eustas, dissected plateau, mesas and buttes with well developed scarp retreats formed in eroding Cretaceous Winton sediments capped by the Tertiary Glendower formation. The back slopes merge with the surrounding undulating plains. The soils are predominantly lithosols and shallow red earths. Silcrete stone cover and silcrete boulders are common. Vegetation ranges from mulga (*Acacia aneura*) tall open shrubland to bastard

mulga (*Acacia clivicola*) low open shrubland on the upper slopes, to lancewood (*Acacia petraea*) and bastard mulga on the scarps and frequently gidgee (*Acacia cambagei*) on the lower scarp retreat slopes.

Abutting, and extending from the dissected residuals are hard mulga lands formed on undulating plains. Two hard mulga lands are found in the study area; Wanko (H3) and Bingara (H4). The Wanko land system is formed on gently undulating convex plains derived from the Tertiary Glendower formation. It is found to the west and south of L. Wyara. In some Wanko land systems other hard mulga or alluvial land systems occur as minor elements. Soils are shallow to moderately deep, acid, stony red earths with bouldery lithosols on the ridges. The vegetation is predominantly sparse mulga tall open shrubland. The Bingara land system occurs as the minor system within the Grey or Wanko land systems. It is found on the tablelands and on gently sloping undulating convex plains. Soils are shallow to moderately deep, acid, stony red earths with variable silcrete cover. Vegetation is predominantly rock grass (*Eriachne mucronata*), mulga, western bloodwood (*Eucalyptus terminalis*) open tussock grass.

Small areas of soft mulga lands are found in the study area. They are formed on alluvia, pediment mantles and fans. Some of these areas also have a significant aeolian influence. The Boran land system (M1) is a minor partner with the Cooloo land system in the floodplain of Taleroo creek to the south of L. Wyara. It is a flat, run-on area associated with mulga lands to the north and south. Soils are predominantly earthy loams although some red, texture contrast soils occur. The vegetation is predominantly mulga tall open shrubland commonly with poplar box (*Eucalyptus populnea*).

The Bierbank land system (M2) consists of low sloping plains of redistributed detritus. On the lower slopes it may merge with alluvial land systems and on the upper slopes it abuts dissected residuals or hard mulga lands. Within the study area it is represented by two small pockets at the base of the low hard mulga ridge to the south of Lakes Wyara and Numalla.

Two mulga sand plain land systems are found in the study area; Greenmulla (S1) and Eulo (S2). The Greenmulla is found to the northwest and south of L. Wyara. It is a system of aeolian derived sand plains of low relief. Soils are deep, acid to neutral sandy red earths with texture contrast soils in local depressions and shallow red earths on bedrock outcrops. The vegetation varies from woollybutt grass (*Eragrostis eriopoda*), mulga, western bloodwood open tussock grassland to mulga tall open shrubland. The Eulo land system is found the south of L. Wyara and to the south and east of L. Numalla as the major land system, and between and south of the lake as the minor occurrence in the Dynevov land system. It contains low relief plains of aeolian derived sand interspersed with clay alluvia and small claypans. Soils are alkaline, deep, sandy red earths often with ferruginous hardpans. Sandy red earths are associated with low, irregular dunes. Loamy

red earths in depressions, also occur. Vegetation is mulga, poplar box tall open shrubland.

In low areas to the east, west and south of L. Numalla, extensive low dunefields, form the Dynevor (D7) land system. This land system is characterised by low dunes intermixed with claypans and playa lakes with soils of red, earthy sands. A well developed mulga tall open shrubland grows on the dunes with woody species on the eroded edges. The Bindegolly (D8) land system has formed as an arc on the eastern side of L. Wyara. The soils here are gypseous, calcareous sands supporting saltbushes, bassias and samphire low shrubland.

The Paroo Alluvial Plains land system (W7) is represented in two small localities; where Werewilka Ck exits into L. Wyara and to the southeast of L. Numalla where Carwarra Ck extends from the Paroo R. This land system has deep braided river channels with small interchannel plains and poorly drained swamps. The channels often flood. Soils are a complex mixture of alluvial grey clays, alluvial soils and texture-contrast soils. The vegetation is a complex of river red gum and coolabah fringing the major channels, and gidgee and yapunyah (*Eucalyptus ochrophloia*) on adjacent areas. There is a restricted occurrence of the Cooloo (W6) alluvial plains land system in the floodplain of Taleroo Ck, adjacent to hard mulga lands, south of L. Wyara. This land system has broad floodplains with few drainage lines. Soils are gilgaied grey and brown clays with gidgee low open woodland vegetation.

Drainage channels fall within the land zone classification of other alluvia. Two other alluvia land systems, Nooyeah (A3) and Warry (A6) are within the study area. The Nooyeah system is a minor occurrence within the hard mulga system to the west of L. Wyara and consists of frequently deflated alluvial plains within which low rises of aeolian material may occur. Claypans and saltpans are also found. The soils comprise brown and grey clays and texture contrast soils with scalded and thick surface crusts. Vegetation is sparse with bassias and saltbushes colonising in favourable times. The only occurrence of the Warry land system is in the upper reaches of Sawpit Ck to the northwest of L. Wyara. This land system comprises alluvial plains characteristic of small streams. The soils are a mixture of texture contrast soils with medium textured alluvia. Vegetation is variable.

The major lakes throughout the area form part of the Lake Pure (L1) land system. Soils range from grey and brown alluvial clays to saltpans. Vegetation is variable, with bassias, saltbushes, bluebush (*Chenopodium auricomum*), and channel millet (*Echinochloa turnerana*) on the clays with canegrass and samphire and canegrass on the massive clays and saltpans.

## APPENDIX 2

The reconnaissance was undertaken to record: the types archaeological evidence found in the study area; the density and distribution of stone artefacts; the types of artefacts found; the raw materials used for the manu-

facture of artefacts; and, the relationship between the archaeological evidence and its environment (environment in this sense refers to both the depositional and postdepositional environment as well the general environment of the study area).

One hundred and twenty kilometers of now random traverses were made across the study area (Fig. 2). These were a series of five-metre-wide straight line traverses between two easily identified, pre-determined points, conducted either on foot or by motorbike. Information recorded included traverse bearing; beginning and end grid references; total distance travelled; artefact densities; distance from starting point to features or artefacts; land system; vegetation type; amount of ground cover and the type of exposure. Notes were also made on raw material and artefact types (Robins, 1993; Appendix 1). Criteria for artefact identification are presented in Robins 1995:666. Figs 3a-c illustrate artefact distributions and their relationship to topography and environment.

This survey recorded large numbers of artefacts distributed differentially across the landscape. Average densities range from extensive, low density scatters with mean densities from as low as 0.005/m<sup>2</sup> to concentrated areas with mean densities of up to 300/m<sup>2</sup> (Figs 3 a-c).

Artefacts occur in five broad patterns:

a) High dissected residual (R3) and hard mulga land (H2/H3) systems to the west and south of the Lakes Wyara and Numalla, carry a low-density scatter of artefacts ranging from between 1/40,000m<sup>2</sup> to 1/50m<sup>2</sup>. Higher densities occur near outcropping silcrete.

b) In the hard mulga lands to the west of the lakes, a ribbon pattern of artefact distribution of medium density (up to 20/m<sup>2</sup>), is associated with the streams flowing into L. Wyara. Generally, the highest artefact densities are associated with semi-permanent waterholes in the mid-course of the streams. The densities taper off towards the dissected residuals at one end and the salt lake at the other. Artefacts are usually present on only one side of the creek at any given location (generally on the inner bends) with the greatest concentrations within 200 m of the creek bed.

c) There are low to medium-density (1/10m<sup>2</sup>-1/1m<sup>2</sup>) clusters of artefacts around the edges of claypans throughout the dunefields (D7, D8);

d) Isolated artefact finds or hearths are scattered throughout the sandplains (S2) and dune fields.

e) Wherever springs (including mound springs) occur, they are associated with extensive, high density (up to 300/m<sup>2</sup>) artefact scatters. Higher density sites have greater artefact type diversity.

There are few artefacts in the vicinity of L. Wyara and only patchy, low density concentrations in the vicinity of L. Numalla. Hearths are generally restricted to the lower lying country, generally associated with creek beds in the hard mulga land systems or claypans within the dunefields and sandplains.

Eighteen types of artefacts were recorded: single and multiplatform cores; flakes; retouched flakes; tulas; pirri points; unifacial points; backed blades; mortars;

pestles; mullers; grindstones; hammerstones; edge ground axes; cylindro-conical stones; ground ochre nodules; and, stone and clay hearthstones.

The majority of artefacts were manufactured from silcrete. Silcrete occurs in three forms; parent rock outcrops, gibber and creek cobbles. Parent rock outcrops generally occur in the dissected residuals and hard mulga lands. They are particularly common in escarpment areas where erosion has exposed them, but they commonly occur throughout both these land systems as outcrops. Silcrete gibber is ubiquitous in the dissected residuals and hard mulga lands but rare in the sandplains and dunefields. It can occur in sizes varying from the rare boulder of up to 1m in diameter to small pebbles. Stones in the 10-20cm size range are common. Creek cobbles derived from the gibber are redistributed along stream lines into the dunefields and sandplains. Other raw materials were infrequently observed. These include: chert (flakes and retouched flakes); sandstone (as mullers, grindstones and cylcons); granite (as grindstones); and nodules of red iron sesqui-oxide (as ochre).

More than 90% of the artefacts noted were flakes. The largest flake was 100mm long and the smallest were microchips of <1mm in length. The largest and smallest cores were 110mm and 10mm respectively. These sizes suggest exploitation of the local gibber and creek cobbles, where the raw material size determines the upper limits of artefact size.

The majority of artefacts were recorded where ground cover was less than 30%. However, over 90% of all the transects had less than 30% ground cover and the correlation between artefact recording and of ground cover was not strong. The relationship between erosion was much clearer. Apart from the low density scatters of artefacts in the gentle slopes and plateau areas within the dissected residuals, all artefacts were associated with erosion in the form of gullying, sheet wash or wind deflation.

The three widely-spaced localities associated with a spring, with varying distances to stone sources, were selected for more detailed assessment. Each had dense and extensive artefact scatters. The aims of this survey were twofold. The first was to confirm and enhance the information obtained during the transect survey through more systematic observations. The second was to assess field recording methods. By choosing sites with large numbers of artefacts, recording methods could be evaluated while potential factors influencing artefact variation could be explored. To do this a proforma, based on one developed by Hiscock & Hughes (1983) was used. No artefacts were collected at this stage of the research. A brief description of these sites and a summary of the results is presented below.

Youlain Springs is located on Youlaingee Ck. This creek rises in the dissected residuals to the west of L. Wyara and flows into its western side, approximately 6km to the east (for more details of this site see Robins, this volume). Two 10m x 10m quadrats were laid out on a bench of sand and desert loam on the south side of the creek approximately 150m west of the junction. The nearest sources of stone were cobbles on the creek

bed and gibber on the undulating plain, both sources 30m-50m from the quadrats. The nearest sources of water were the spring (now destroyed) and the pools in the creek.

Kaponyee Springs is situated on a low rise in dunefields approximately 5km south east of L. Wyara, 5km south west of L. Numulla and 500m north east of Kaponyee Ck. The focus of the site is a number of low mound springs (now dried up) that have erupted in plains with low rounded dunes interspersed with claypans. The general area has been extensively modified by European development and erosion in places had created gullies. Despite this disturbance, a large scatter of artefacts and a number of hearths could be found within a 1-km-arc north east of Kaponyee Ck, centred on the springs. The nearest source of stone from the site are the silcrete gibbers in the hard mulga lands and associated creek systems, approximately 3km to the south. Three 10m x 10m quadrats were laid out over a bare, eroded, gently sloping surface bounded by sand dunes from which artefacts were eroding.

Bokeen Bore is situated in dunefields with low dunes and claypans with lignum, approximately 7km south east of L. Numulla and one kilometre east of L. Kaponyee. A large scatter of artefacts, approximately 1km<sup>2</sup>, is eroding out of sandhills onto the aprons of claypans. There is some evidence in the form of mineral impregnated sand upwellings, that a number of soaks operated in the area at some time in the past. The nearest source of stone is the silcrete gibber of the undulating plains in the hard mulga lands approximately 3km to the west. One 10m x 10m quadrat was laid out on a claypan apron above which was a dune from which artefacts were eroding.

The six quadrats contained 14,552 artefacts; 3,128 and 3,680 at Youlain Springs; 6,314 at Bokeen Bore; and, 746, 520 and 184 at Kaponyee Springs. A crude extrapolation obtained by multiplying the recorded density of artefacts at Bokeen Bore by the area of artefact distribution gives an approximate total surface number of 60 million artefacts. Given the size of these sites and the density of artefacts, meaningful discussion must be limited to generalities.

There is high variability in the numbers of artefacts between quadrats overall, but not between quadrats from the same locality. Bokeen Bore and Kaponyee Springs had high and low densities respectively, with Youlain Springs somewhere in between. Average artefact densities for all quadrats range from 1.8/m<sup>2</sup> to 61/m<sup>2</sup>.

Youlain Springs has the greatest richness of artefact types. These include flakes, retouched flakes, tulas, backed blades, pirri points, unifacial points, edge ground axes, multiplatform cores, grindstones and a muller. At Kaponyee Springs, flakes, retouched flakes, cores and multiplatform cores and one grindstone were recorded. The artefact types recorded at Bokeen Bore were flakes, retouched flakes, cores, multiplatform cores and hammerstones. Knapping floors were not identified at any site. With the exception of grindstones and mullers made on sandstone, the edge ground axes

from basalt and two tulas from chert, all the artefacts are made on silcrete.

At both Kapyee and Youlain Springs there is some variability in the proportion of size classes between quadrats for both flakes and cores. At Kapyee Springs, for example, quadrat 1 has proportions of 10%, 20% and 70% for the flake size classes of 1cm, 1-5cm and 6-10cm, compared with the figures of 70%, 10% and 20% for the same flake size classes in quadrat 3. A similar pattern applies to the cores.

Despite the size variability within sites, overall there is a degree of uniformity in the maximum and mini-

mum size for flakes and cores. The minimum flake size of 1-2mm for all the sites suggests either a limitation in the method of recording of flakes <1mm in size or a postdepositional winnowing process that eliminates small flakes from the record (Cameron et al., 1990). Maximum core size is not a lot more than maximum flake size. This uniformity suggests limitations on core size imposed by the raw material. Raw material uniformity appears to override other factors that might influence the character of the artefact assemblage, such as distance from raw material or the technology used to produce artefacts.