

GIS and Prehistoric Mammal Acquisition Patterns

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Abstract

Geographic information system (GIS) analyses of mammal species' landscape distributions produces species assemblage lists that are comparable with archaeological species assemblage lists. Using digitised environmental maps and associated information entered into attribute tables, GIS analyses identified three (3) species assemblages possibly reflective of prehistoric Aboriginal people's emphases. These were 1) preference for specific landscapes, 2) preference for specific species, and 3) restrictions on time available to travel from an occupation site. Comparisons with an archaeological assemblage from Cathedral Cave in Carnarvon Gorge, (Queensland, Australia) identified differences in the listed species. For example, a dominant species determined from the GIS analyses, the Common Ringtail Possum (*Pseudocheirus peregrinus*, Thomson and Owen, 1904, 27), was ranked 10th in the archaeological species list.

1 Introduction

An implication from previous research undertaken in the Central Queensland Highlands of Australia is that prehistoric mammal acquisition activities occurred from visited sites as a secondary activity. Beaton (1977, 1982, 1991a, 1991b) suggested large amounts of *Macrozamia* husks from his excavations at Cathedral, Rainbow, and Wanderer's Caves indicated intensive *Macrozamia* nut processing. His broader conclusions about the use of *Macrozamia* nuts were linked to increases in ceremonial activities and large gatherings occurring at these and similar sites in the Central Queensland Highlands (Beaton 1977; 1982; 1991b, 82). A synopsis of the Central Queensland Highlands' archaeological research by Morwood in 1984, provide support for varied usage of prehistoric sites including *Macrozamia* nut processing and ceremonial/religious activities.

Based on this scenario, this project asked the question: Was mammal acquisition by prehistoric Aborigines in the Central Queensland Highlands a structured activity or the result of opportunistic encounters while undertaking other activities? Geographic information system (GIS) analysis is employed as the tool used to derive possible acquisition strategies and their related potential species assemblage lists. GIS was selected because mammals are spatially distributed across the landscape. Mammal landscape distributions are affected by the distribution of the mammal's resources (Caughley, et al 1987, Croft 1991, Jarman and Taylor 1983, Johnson 1989, Newsome 1975,

Russell 1984). Resources examined include shelter, food and nesting materials. GIS analysis focuses on availability and accessibility of a species' resources and their resulting effect on species' distributions across the research landscape.

2 Project background

Approximately 2000 km² in the Central Queensland Highlands encompasses the research area. Cathedral Cave, where two excavations were undertaken, is the research area's centrepiece. An archaeological mammal assemblage excavated from Cathedral cave is used for comparison with the GIS generated assemblages. Fourteen land systems represent the landscape microenvironments. They were defined in two Commonwealth Science and Industrial Research Organisation (C.S.I.R.O.) surveys that join at a Northwest - Southeast line (Figure 1.). Lands of the Isaac - Comet Area (Story, et al 1967) profile northeastern land systems. Lands of the Balonne-Maranoa Area, Queensland (Galloway, et al 1974) profile southwestern land systems.

INTERA TYDAC Technologies' SPatial ANalysis system (SPANs) was the GIS program employed as it was designed for use on personal computers (INTERA TYDAC Technologies Inc. 1992). A base map of 1665 km² defines the project's analysis area. Latitude and longitude are defined from geological maps: Eddystone 1:250,000 (SG/55-7) covers the southern study area, and Springsure 1:250,000 (SG/55-3) covers the northern study area (see Figure 1).

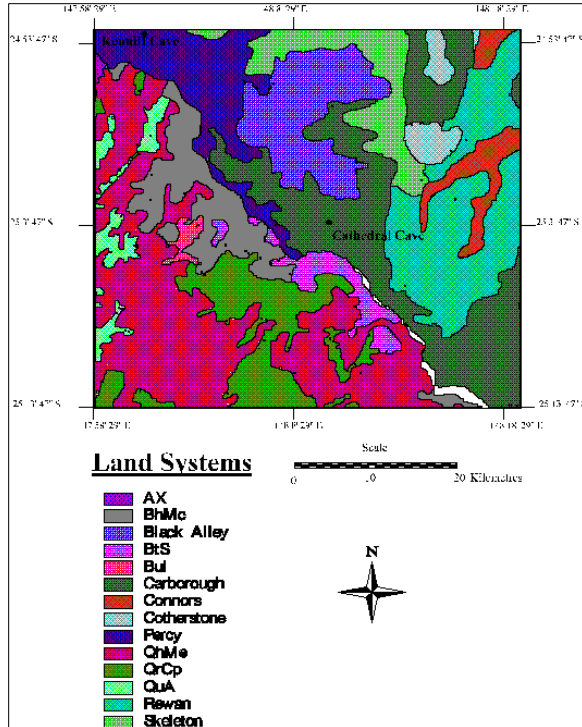


Figure 1. Geographic Information System (GIS) representation of research area land systems.

Raster and vector maps, points, and attribute tables comprise analysis data. Land system maps were scanned. Maps were classified in MicroBrian (Commonwealth Scientific and Industrial Research Organization and Microscopic Applications Pty. Ltd. 1988) and processed into a raster image importable into SPANs. Archaeological sites were entered as point information. Fauna habitat information was entered as attribute tables created in MS-dos editor and Microsoft Excel 4.0.

3 GIS Analysis Methods

Secondary maps resulted from analysis manipulations of primary maps and associated attribute tables. Five types of analyses were performed: area covered, overlay comparison, cross-tabulation, unique conditions, and surface analysis. These analyses are hierarchical: overlay is a higher level of analysis than area determination.

3.1 Landscape accessibility assessment criteria

Surface analysis determined accessibility of resources once their availability was established. Topography is assessed in surface analysis using slope grade percentages. Bailey and Davidson (1983), Lee

(1968), and Vita-Finzi and Higgs (1970) have demonstrated how topography influences resource access: as elevation increases, the time needed to cover a specified distance increases. Hence, habitat accessibility to locate mammal species individuals was determined in SPANs by re-classifying land systems based on the reported slope. Three land system classes resulted:

1. Class one, easy, covers flat to slightly sloping topography encompass alluvial plains and slightly sloping to rolling hills;
2. Class two, medium effort, covers topography with a consistent slope of more than 10 % but up to slopes of < 60 %;
3. Class three, difficult, covers topography with slopes > 60 % including cliffs.

3.2 Species availability assessment criteria

Cross-tabulation of land systems with archaeological species identified from research in the Central Queensland Highlands delimits species' spatial distribution. Species' availability classifications are attributed based on land system descriptions (i.e., Galloway, et al 1974, Story, et al 1967) meeting general habitat, food and nesting requirements described in animal behaviour research for each species (i.e., Caughley 1987, Croft 1991, Newsome 1965, Pople 1989, Short 1987). This separation of species' habitat, food, and nesting requirements enables consideration of partial land system use. Separation of food and nesting requirements from general habitat was made based on research showing mammal landscape use is specific to landscape components and not generalized usage (e. g. Bennett 1993, Coulson 1990, Cowan and Moeed 1987, Jarman, et al 1991, Pople 1989, Quin 1988, Wallis, et al 1989). Availability classifications employed are:

- A. Total habitat, food, and nesting requirements met;
- B. Food requirements met;
- C. Nesting requirements met;
- D. Possible use of land system as a habitat;

These classifications not only distinguish between the presence or absence of a species within a land system but enable partial presence (e.g., seasonality) to be investigated. The respective group of classifications for each land system creates a list of species that would potentially be available for acquisition by

Aboriginal people. In addition, examination of individual land systems sets a baseline for encountering a species' individual within a particular land system. Combining this information with accessibility information for each land system produces potential prehistoric Aboriginal acquisition patterns.

4 Analysis results

4.1 Mammal availability

Species availability within land systems from the perspective of prehistoric Aboriginal people is a function of a mammal species locating their required resources such as food water, shelter, and nesting facilities. The value given to a land system per species represents the presence of different resource combinations within that land system. This value is extrapolated to the likelihood of an Aboriginal encountering a particular species within a land system. Table 1 displays the classification for each species within each land system.

Species / Land System	Increasing Size →																Number of species											
	Tree Dwelling				Non-m acropods				Ground Dwelling				Large macropods															
	<i>Phascogale tapoanifa</i>	<i>Perameles robustus</i>	<i>Pseudochirinus perspicuus</i>	<i>Trichosurus vulpecula</i>	<i>Phascogale chirensis</i>	<i>Isodonta obsoleta</i>	<i>Perameles nasuta</i>	<i>Isodonta macconnisi</i>	<i>Peromyscus trichactylus</i>	<i>Peromyscus parvulus</i>	<i>Brotomys tenax</i>	<i>Hyppomyscus rufescens</i>	<i>Lentorhinus longirostris</i>	<i>Vombatus ursinus</i>	<i>Phyllogale tharui</i>	<i>Perogale thomasi</i>	<i>Perogale pascuiflora</i>	<i>Perogale southwayi</i>	<i>Macropus parryi</i>	<i>Macropus dorsalis</i>	<i>Macropus agilis</i>	<i>Platypus becheri</i>	<i>Macropus rufogriseus</i>	<i>Macropus robustus</i>	<i>Macropus giganteus</i>	<i>Macropus rufus</i>		
QhMe	B	A	A	A		A	D																				12	
Carborough	B	A	A	A		A	D																					12
Rowan	C	B	A	A		B	A	D												C								12
QcCp	B	B	A	A	D	B	B	D													D							15
Black Alley	B	A	D	A		A	D	A	B						A	D	B			A	B		B	B	A	B		20
Perry	C	D	D	D		A	D	A	B						A	B	B	A		A	B	B	B	A	A	B		21
BHMc	A	D	A	A		A	A	A	D						A	A	B	B		A	A		B	A	A	B		20
Skeleton	C	A	A	A	D	D	B	A	A						A	D	B	B	D	D					A	A	D	19
Connors	A	D	A	A	D		D	A	A	A	A				A	A				B	A	A		D	D	A	A	19
BIS	A	D	D	A		A	D	D	A	A	A				D	D	B	B		A	B		A	D	A	B		20
QuA	B	B	A	D		A	A	D	A						C	A	A			C	A	A	A	A	B	A	A	17
Colterstone	B	D	A	D		A	A	D	A	D					D	A	A	A		B	B		A	A	A	B		20
Bul	C	D	A	A	D		D	A	A	D					B	B	B			B	D	B	B	B	B	A	B	21
AX	A	D	B	D		D	D	A	A	A					A	B	B	B		B	A	B	B	B	B	A	A	22
Number of Land Systems	14	12	8	14	2	12	6	14	8	10	10	12	8	9	11	9	10	1	12	7	6	8	12	10	13	12		

Figure 2. Potential availability of species within all Land Systems in the research area.

Differential distribution of mammal resources across the landscape leads to differential distribution of mammals among the land systems. Hence there are degrees of mammal availability that Aboriginal exploitation patterns may or may not take advantage. Three strategies are suggested from the land system - mammal potential availability values shown in Figure 2:

1. the number of species potentially available within a land system,
2. the number of land systems a species is potentially available in,

3. restriction of species/land systems utilised if there are time/distance constraints on acquisition activities.

4.1.1 Strategy 1: number of species within a land system

Strategy 1's focus is the exploitation of mammal species potentially available particular land systems. Each land system has a group of species potentially available for acquisition by Aboriginal people. The number of species within each land system varies from twelve (12) to twenty-two (22) (see Figure 2) out of a total of twenty-six (26) species identified from Central Queensland Highlands' archaeological assemblages.

Two sub-strategies arise from utilising a land system with respect to species potentially available: (a) go to the land system with the most species; (b) go to the land system with the most species having the highest potential availability rating (see Figure 2). Figure 2 shows that none of the land systems has the exact same group of species potentially available. To identify which land systems were visited, an assumption is made that each species in the land system would be encountered at the same rate, a rate specific to that land system. Furthermore, it would be expected each land system would be visited with respect to the number of individual mammals encountered irregardless of which mammal species Aboriginal people acquired in the land system (e.g., Hill, et al 1985, O'Connell and Hawkes 1981, Smith 1987, Winterhalder 1983). The expected archaeological mammal species assemblage from such strategy 1(a) would reflect the species proportions in each land system.

Strategy 1(b) refines this approach by subtracting the assumption that all species would be encountered at the same rate. This strategy focuses on the land system with the most number of species with the highest potential availability rating (A). Species' potential availability does vary within each land system as a function of resources each land system offers a species. Ignoring this aspect of mammal resource exploitation as strategy 1(a) does results in lost acquisition time. Encounter rates for all species within the land system will increase, as a function of some species being in the land system less than others because resources mammals rely on may not be readily available. Hence, the land system with more species that have a (A) availability rating will have a higher overall encounter rate. Prehistoric Aboriginal people focusing their acquisition energies

on these higher rated species would create an archaeological assemblage with a smaller range of species diversity than that of strategy 1(a).

4.1.2 Strategy 2: number of land systems containing a species

Strategy 2 focuses on mammal distributions and potential Aboriginal people's preference for a species. There is no inference as to why a species is acquired under this strategy other than that the number of land systems a species can be found in thus increasing the species' encounter rate across the landscape. The ideal for acquisition strategy 2 is to have a species available in all land systems. As for strategy 1, there are two components to strategy 2: (a) the distribution of mammal species across land systems, and (b) the species' potential availability rating within a land system. Figure 2 demonstrates only three species are potentially available in all fourteen land systems: Brush-tailed Phascogale (*Phascogale tapoatafa*), Common Brushtail Possum (*Trichosurus vulpecula*), and Northern Brown Bandicoot (*Isodon macrourus*). An archaeological assemblage created from strategy 2(a) would primarily consist of these three species as they would always be encountered.

Considering strategy 2(b), Figure 2 demonstrates the varied potential availability of each species in each land system is not the same. This implies these species will not have an equal encounter rate within each land system. The Common Brushtail Possum (*Trichosurus vulpecula*) has the highest number of land systems, eight (8), with an (A) potential availability rating. The species with the second highest number of land systems with a (A) potential availability rating is the Northern Brown Bandicoot. It has a (A) potential availability rating in six (6) land systems. Assuming archaeological assemblages reflect land system species proportions, an assemblage based on strategy 2(b) would result in the Common Brushtail Possum dominating the assemblage.

4.1.3 Strategy 3: time/distance constraints

Strategy 3 considers suggestions from previous research that mammal acquisition was a secondary activity constrained by participation in other activities such as processing *Macrozamia* nuts and undertaking ceremonial/religious activities (e.g., Beaton 1977; 1991a; 1991b; Morwood 1984). It is expected a fauna assemblage would reflect species located primarily in local land systems with exotic species coming from distant land systems. The effects of time/distance

constraints are demonstrated by examining land systems within a ten (10) kilometer radius of Cathedral Cave. There are nine (9) land systems within this radius (see Figure 3) versus fourteen (14) for the research area (see Figure 2).

Species / Land System	Increasing Size →																										
	Tree Dwelling			Non-macropods			Ground Dwelling				Large macropods																
	<i>Phascogale tapoatafa</i>	<i>Petauroides volans</i>	<i>Trichosurus vulpecula</i>	<i>Phascogale cinerea</i>	<i>Isodon obauar</i>	<i>Perameles nasuta</i>	<i>Isodon macrourus</i>	<i>Petroirus tridactylus</i>	<i>Bettongia penicillata</i>	<i>Bettongia lesueur</i>	<i>Apporpyrum rufescens</i>	<i>Lantornis brydii</i>	<i>Combatus varians</i>	<i>Phyllogale thetis</i>	<i>Petroirus normani</i>	<i>Petroirus penicillata</i>	<i>Perameles santschyni</i>	<i>Macropus parryi</i>	<i>Macropus dorsalis</i>	<i>Macropus agilis</i>	<i>Pellebete bicolor</i>	<i>Macropus rufogriseus</i>	<i>Macropus robustus</i>	<i>Macropus giganteus</i>	<i>Macropus rufus</i>	Number of Species	
QhMe	B	A	A																							12	
Carburugh	B	A	A																								12
Rewan	C	B	A			B	A	D			C	D	D						C						D	D	12
Or-Cp	B	A	A	D		B	A	D	D		C							D			D				D	D	15
Black Alley	B	A	D		A	A	D	A	B	B	B			A	D	B	D		A	B	B	B	B	A	B	A	20
Perry	C	D	D		D	A	D	A	B	A	D	A	B	B	A	B	B		A	B	B	B	A	A	B	A	21
BhMe	A	D	A	A		A	A	A	A	A	B	A	B	A	A	B	B		C	B	A	B	A	A	A	B	20
Skeleton	C	A	A	A	D	D	B	A	A		D		B	B	D	D	D		C	B	A	A	A	A	A	D	19
BIS	A	D	D	A		A	D	D	A	A	D	D	B	B	B	B			A	B	A	D	A	A	D	B	12
Number of Land Systems	9	8	4	9	1	7	5	9	4	5	6	7	4	7	7	7	11	7	4	1	5	7	5	8	7		

Figure 3. Potential availability of mammal species in land systems within a 10 kilometer radius of Cathedral Cave.

Figure 2 for the entire research area, shows Eastern Grey Kangaroo (*Macropus giganteus*) and Brush-tailed Bettong (*Bettongia penicillata*) has the highest number of land systems with a potential availability rating of (A): ten (10) and nine (9) respectively. In contrast, the Common Brushtail Possum (*Trichosurus vulpecula*) has the largest number of land systems, six (6), with the highest potential availability rating (A) within 10 kilometers of Cathedral Cave (see Figure 3). Three other species come in second with (A) ratings for five (5) land systems: the Greater Glider (*Petauroides volans*), Brush-tailed Bettong (*Bettongia penicillata*), and the Eastern Grey Kangaroo (*Macropus giganteus*). Moreover, examining which of these species has the highest average potential availability rating shows the Brush-tailed Bettong with its (A) rating in five land systems would be encountered the most (see Figure 3). The other three species' (A) ratings are offset by (B) and (D) ratings that reduce their average encounter rate. Hence Brush-tailed Bettongs are expected as a major contributor to the Cathedral Cave archaeological fauna assemblage if prehistoric Aboriginal people employed strategy 3.

4.2 Mammal accessibility

Accessibility affects strategy 3 the most where time/distance constraints would result in easy to access land systems being utilised to minimise time away from other activities. The impact accessibility has on time/distance constraints is further emphasised by examining land system accessibility within five (5) kilometers of Cathedral Cave (Figure 4). There is

only one land system within five kilometers of Cathedral Cave that does not have a class 3 (difficult) accessibility rating (land system Black Alley - 2). Class 1 (easy) land systems are not accessible and hence, not expected to contribute to an archaeological assemblage by increasing the number of species individuals.

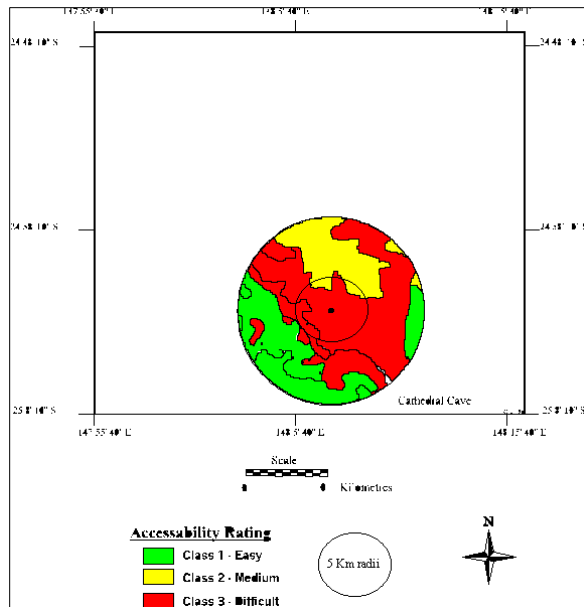


Figure 4. Land system accessibility ratings within 10 kilometers of Cathedral Caves.

5 Analysis and conclusions

Three strategies for the acquisition of a mammal species individuals are proposed by GIS analysis techniques. These strategies are expected to create distinctive patterns within archaeological fauna assemblages if prehistoric Aboriginal people living at Cathedral Cave exclusively followed any one of these strategies. Strategy 1, where acquisition activities focused on the number of species potentially available within a specific land system, would result in a restricted group of species with similar habitat requirements being the dominant fauna in an excavated assemblage. Strategy 2, where acquisition activities focus on the number of land systems a specific species is potentially available in, would create a hierarchical fauna assemblage with a dominant species and few habitat similarities between

the dominant and sub-dominant species in the assemblage. Strategy 3 includes the effect of constraints or restrictions on the time/distance a person travels to acquire mammal species individuals. This last strategy would create the most distinctive fauna assemblage because the number of land systems in the research area that are accessible within the time/distance constraints are reduced, subsequently the potential availability rating produces more of an impact on which species are encountered. This strategy results in the formation of a distinctive hierarchical fauna assemblage but with more variation in the level of similarities in identified species' habitats.

All three strategies produce an encounter rate affected by the potential availability of a species within a land system. This encounter rate is what is perceived by prehistoric Aboriginal people during their acquisition activities and while they performed other activities that enabled them to observe the number of individuals of a species within the occupation site area. What enhances this perception is observance of species presence indicators. Indicators such as the availability of grazing and browse material, nesting sites, and vegetation density all contribute to identification of species presence within an area and could influence prehistoric Aboriginal people to focus on specific mammal species.

Encounter rates are also influenced by accessibility to the area where a species is potentially available. Restricting the time/distance an Aboriginal person travels to acquire a species individual reduces encounter rates because the number of land systems reachable within the time/distance constraint is diminished. Compounding this time/distance restriction is how accessible a land system is: a land system easy to traverse will be used more than one that is difficult because more time can be employed in searching for prey in the easy to access land system.

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